A CAHNERS PUBLICATION INTERNATIONAL EDITION MAY 29, 1986

EDN

29 JUNI 1986

SPECIAL ISSUE: Analog technology

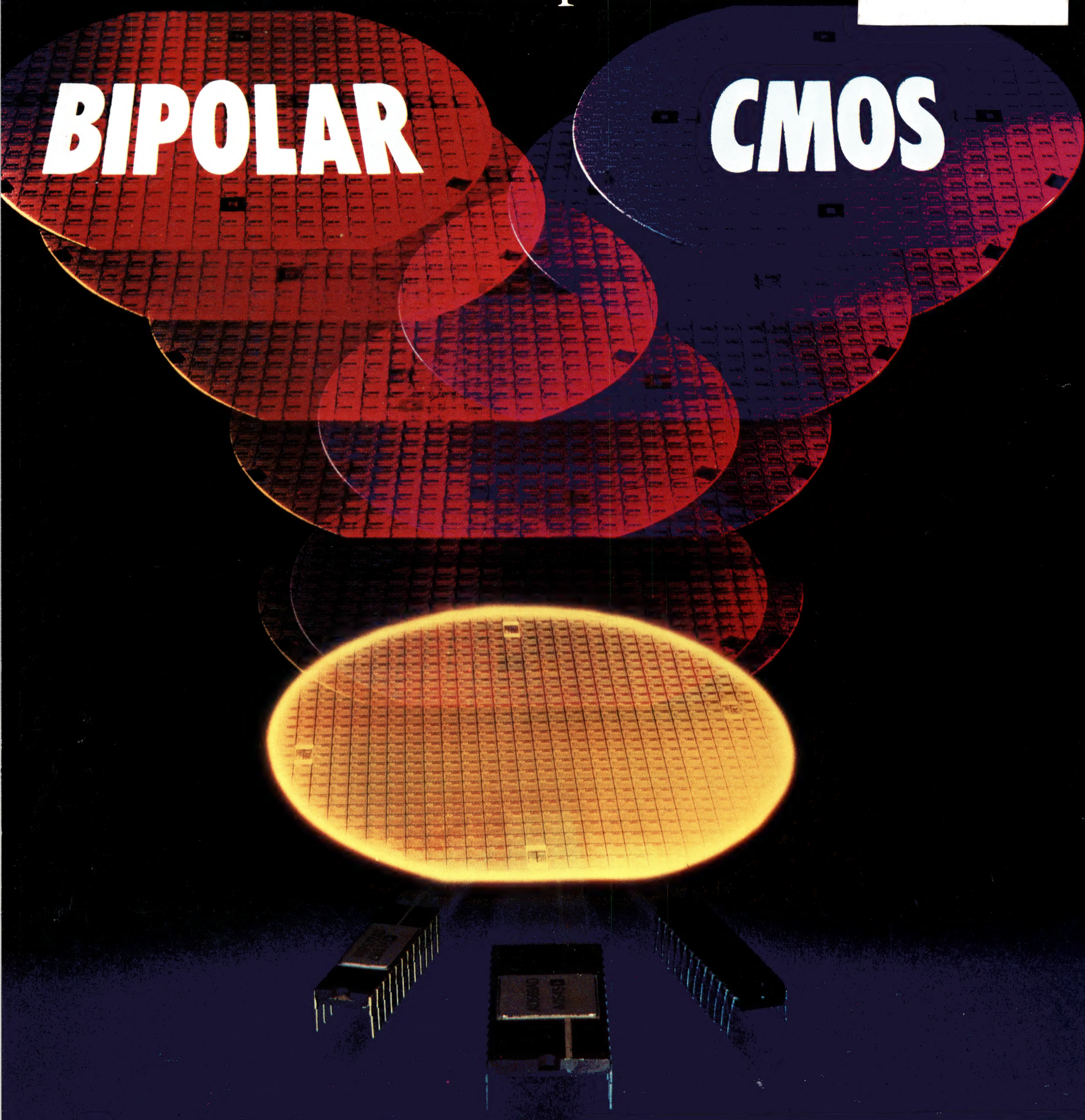
DC-stabilized CMOS op amp operates from ±15V supply

Analog-CAE functions range from simulation to layout

Linear voltage regulators

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

Merging technologies enhance data-converter performance



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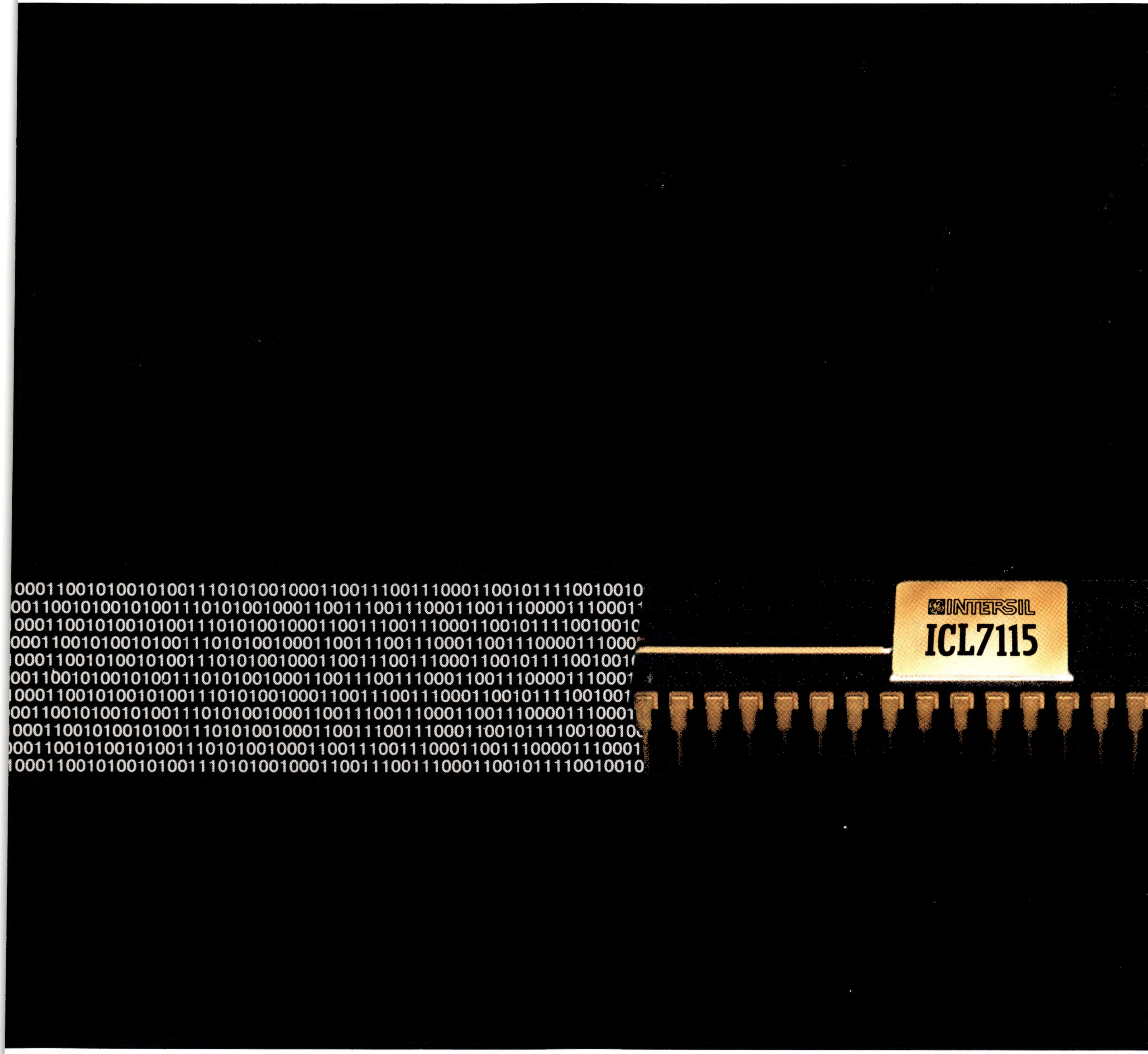

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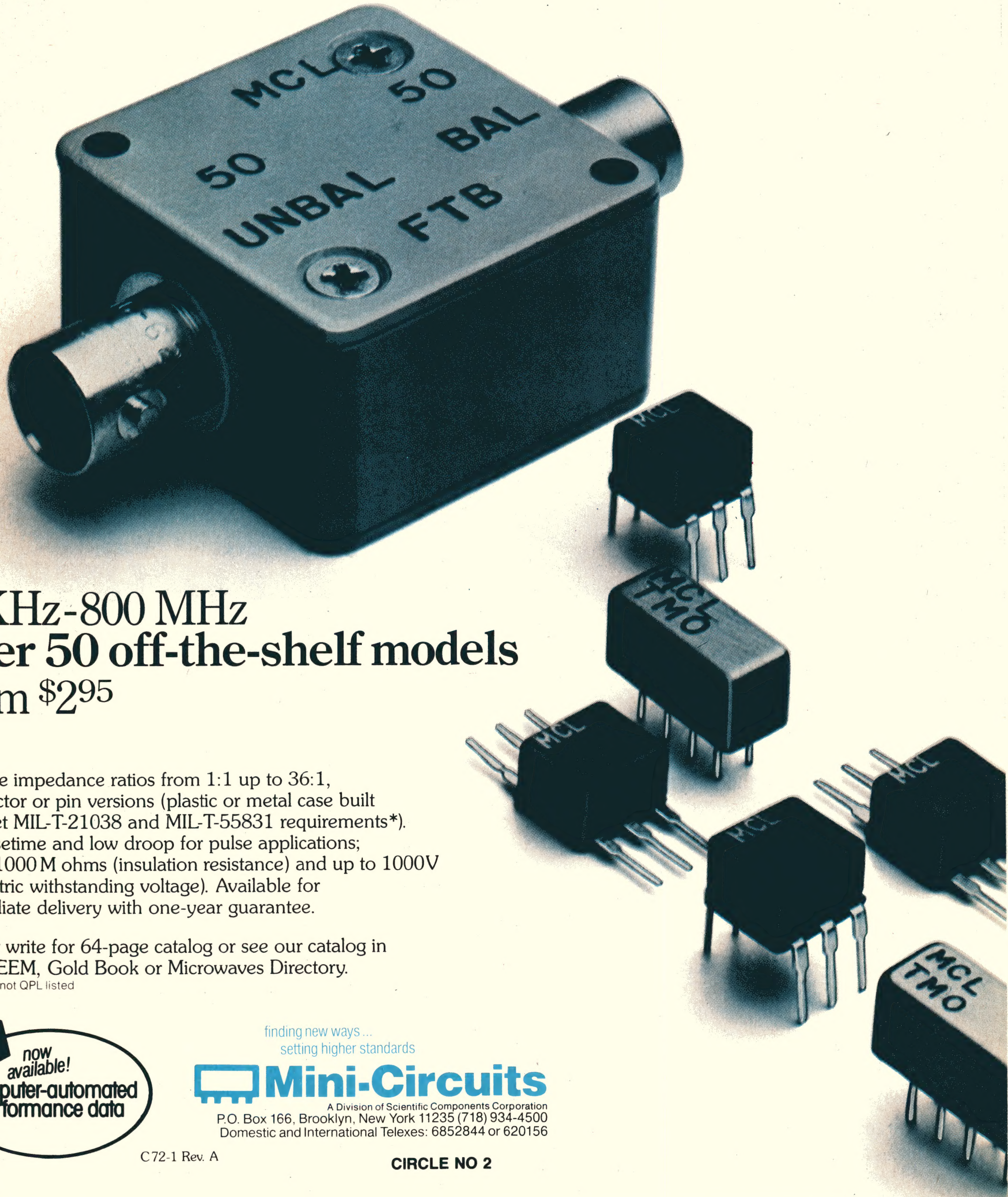

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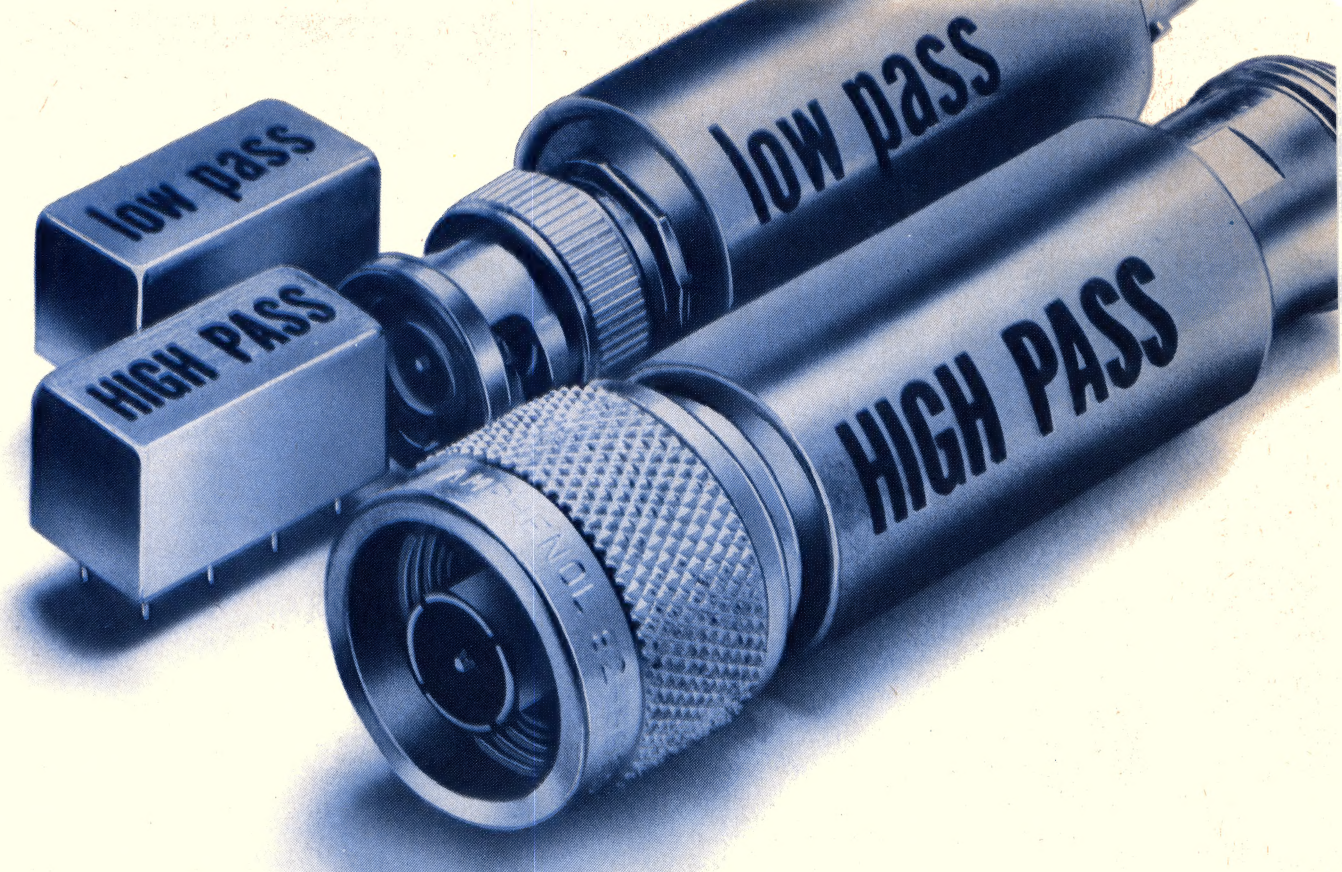

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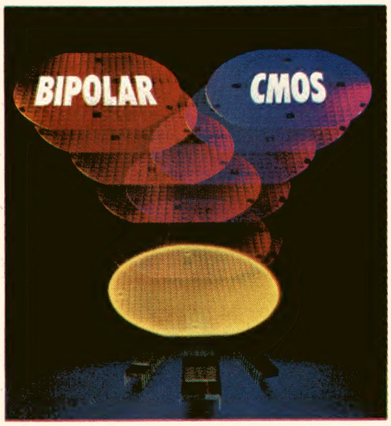
Volume 31, Number 11

EDN

May 29, 1986

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



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DESIGN FEATURES

Continued on page 7

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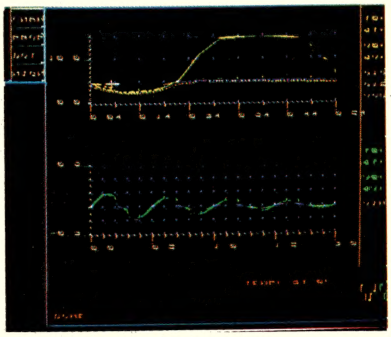

***Analog-CAE tools** are becoming easier to use, and they're offering extended libraries of standard linear parts (pg 49).*

TECHNOLOGY UPDATE

PRODUCT UPDATE

DESIGN IDEAS

Continued on page 9

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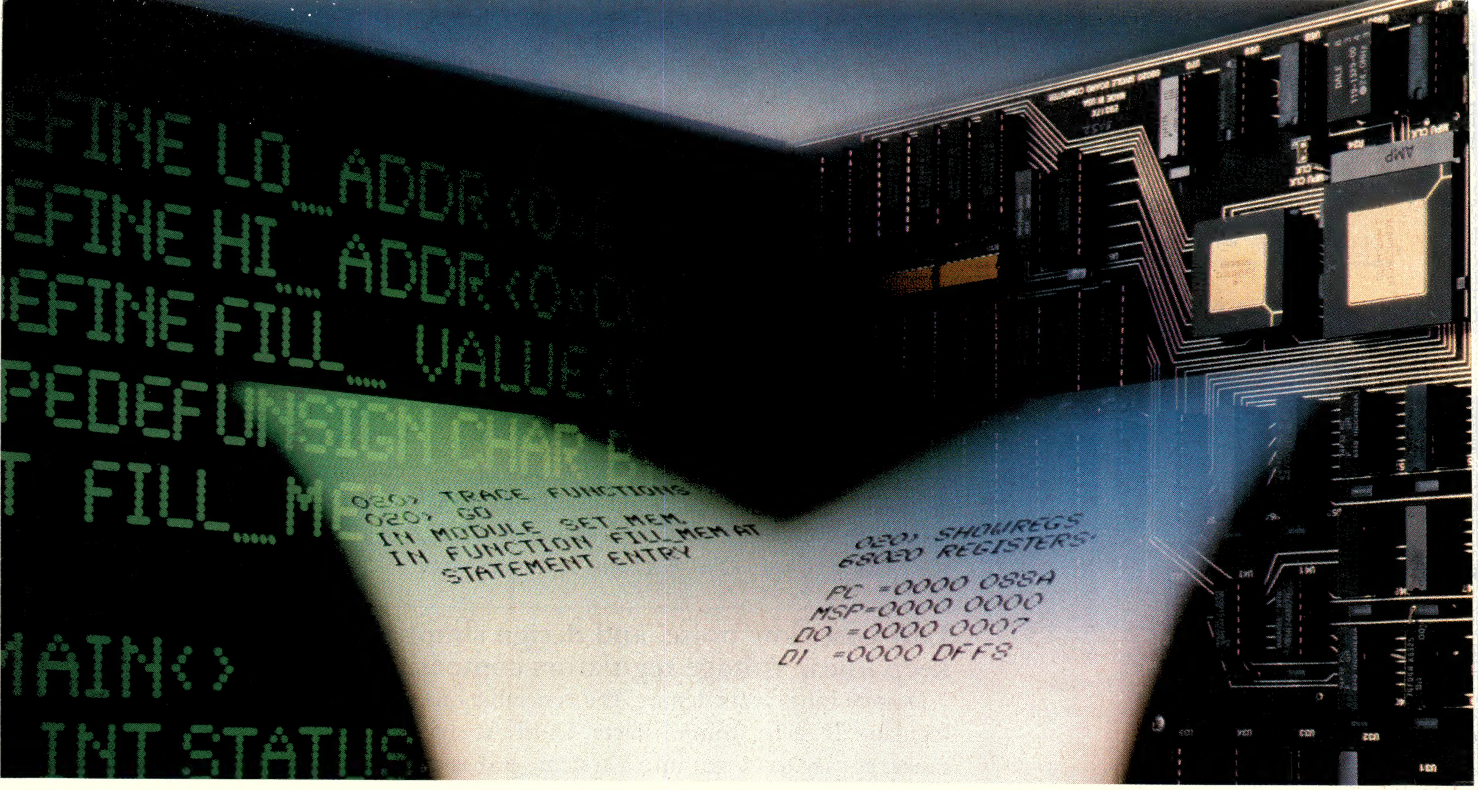

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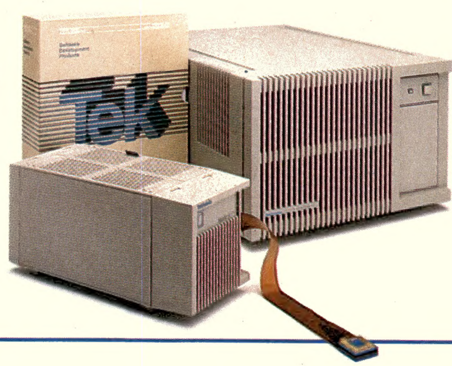

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EDITORIAL 45

Each year, EDN publishes several special issues that concentrate on specific topics. The analog and digital issues are often accompanied by editorials and letters to the editor that tout or bemoan the demise or ascendancy of analog or digital technology. But what strikes us this year is the increasing difficulty of identifying "analog" and "digital" articles to include in these issues.

NEW PRODUCTS

PROFESSIONAL ISSUES 259

Efforts to draw minorities to engineering make progress but still face obstacles.—*Deborah Asbrand, Staff Editor*

LOOKING AHEAD 273

Market niches key to growth in US switch market . . . Europe semi makers rebound via start-ups and alliances.

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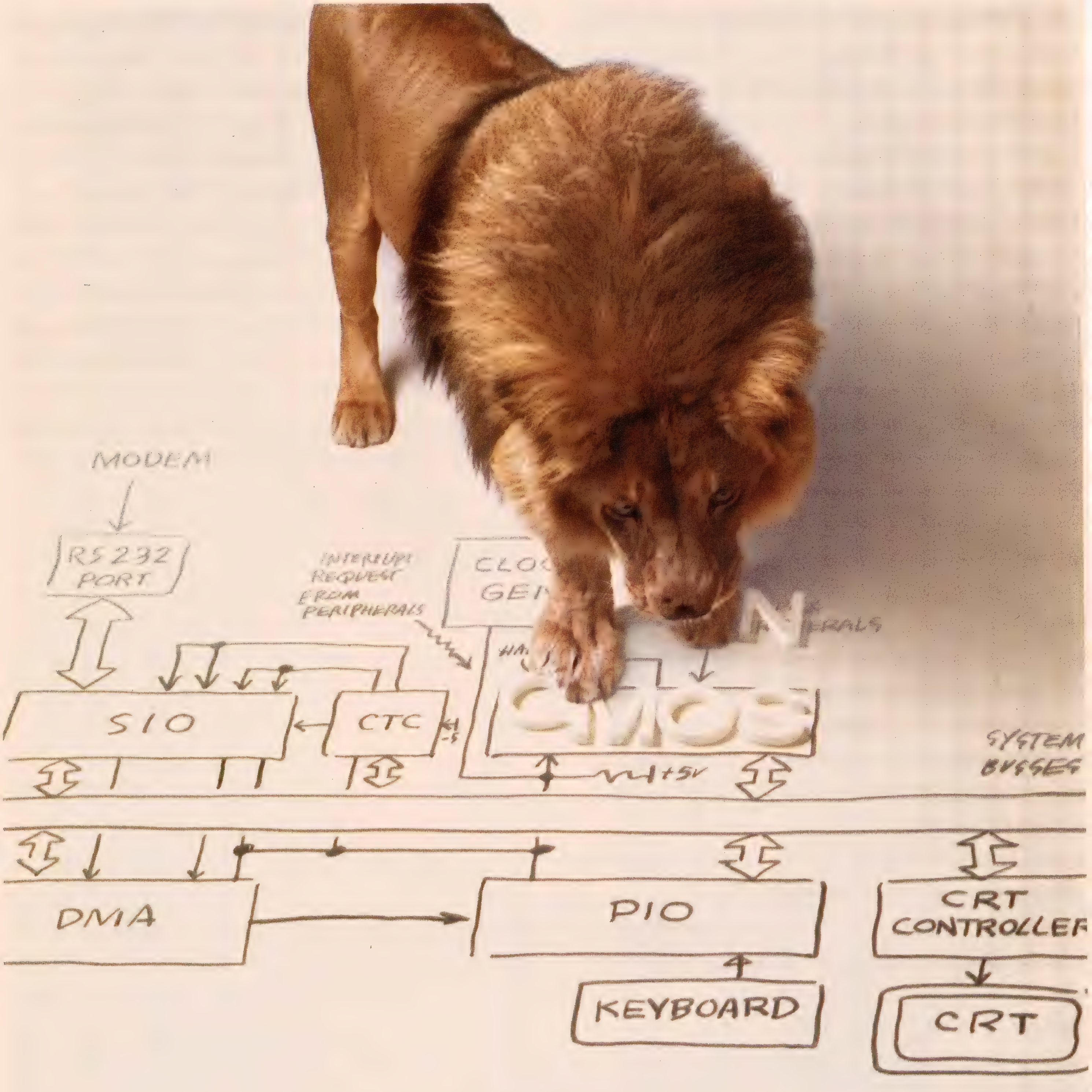

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Device	Description	Technology	Operating Current at 4MHz	Power-Down Current
TMPZ84C00	4MHz Z80A CPU	CMOS	15mA	$<10\mu A$
TMPZ84C30	CTC: Counter/Timer Circuit	CMOS	3mA	$<10\mu A$
TMPZ84C20	PIO: Parallel Input/Output Controller	CMOS	2mA	$<10\mu A$
T6497	Clock Generator/Controller	CMOS	2mA	$<10\mu A$
TMPZ84C40	SIO: Serial Input/Output Controller	CMOS	25mA	$<10\mu A$
TMPZ84C10	DMA: Direct Memory Access Controller	CMOS	25mA	$<10\mu A$

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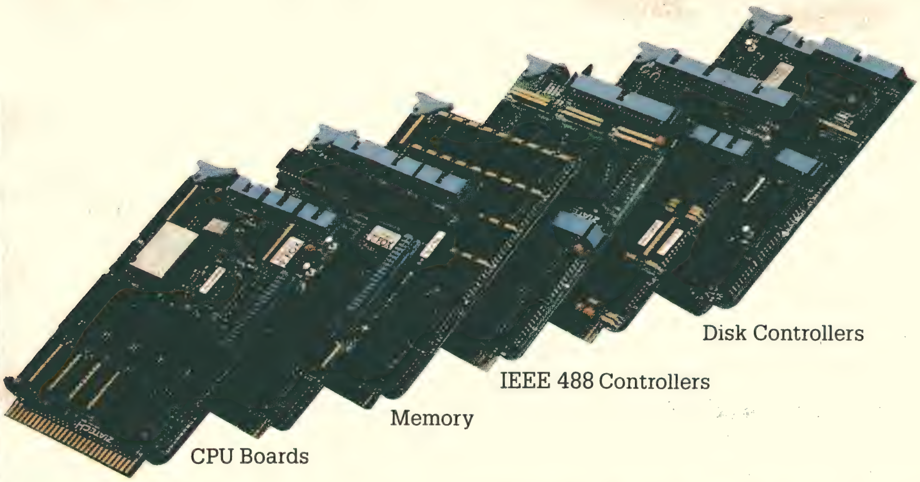

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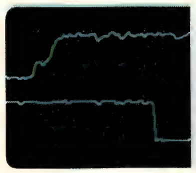
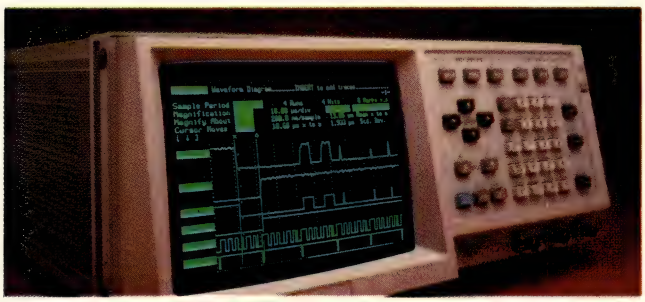


The HP 1631 A/D.



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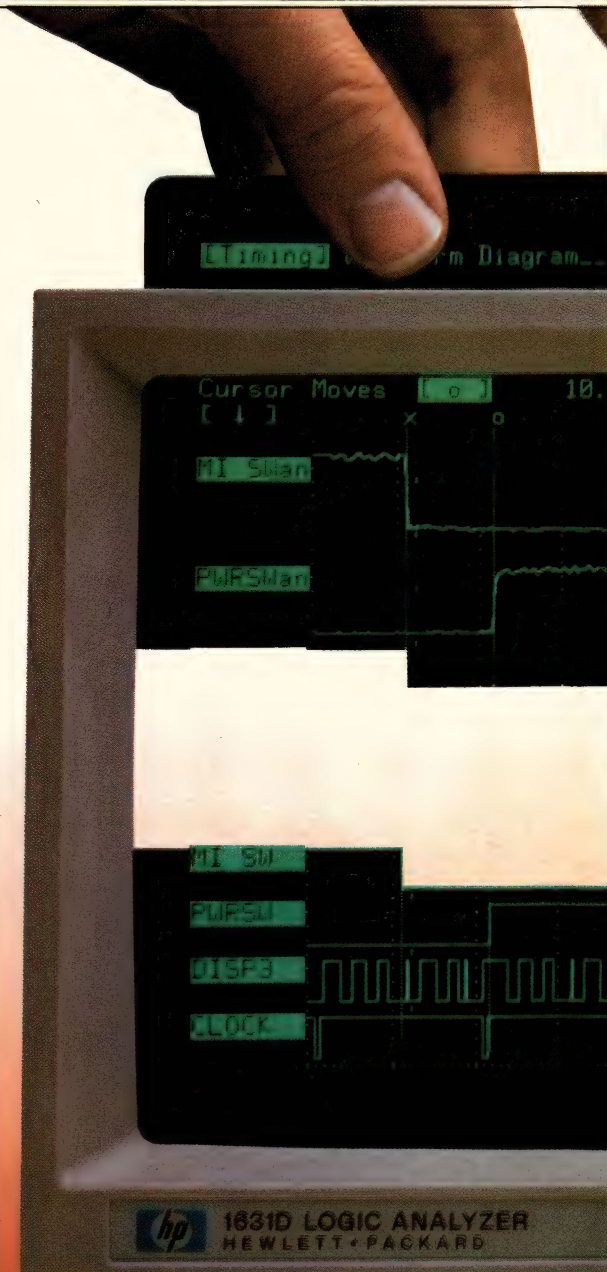

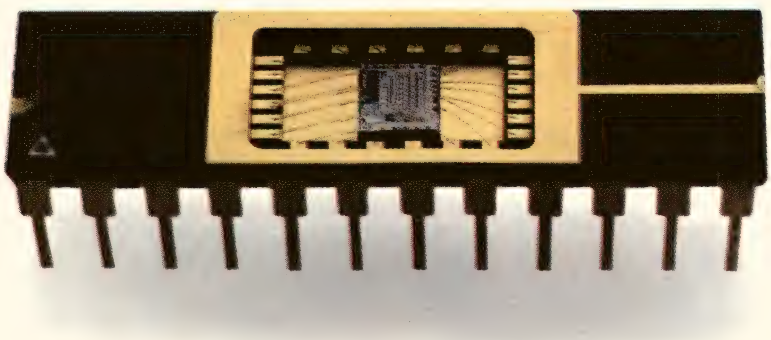

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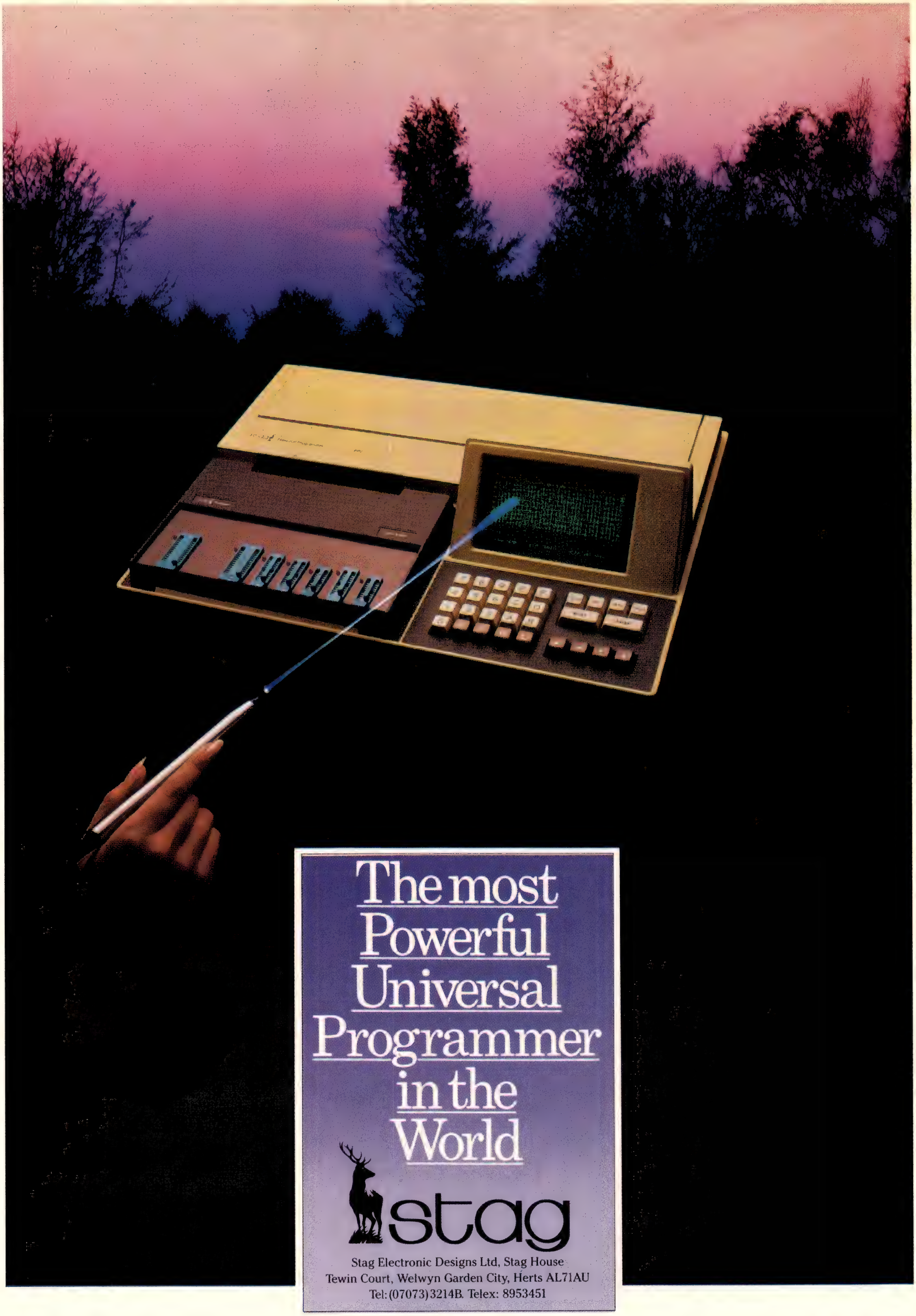
ANALOG DEVICES

CIRCLE NO 6



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NEWS BREAKS

EDITED BY GEORGE STUBBS

GRAPHICS CARDS, HIGH-CAPACITY DRIVES DEBUT AT COMDEX

Graphics cards and high-capacity hard-disk drives for IBM PCs and compatible computers were the stars at the recent Comdex Spring exhibit in Atlanta. Clones of IBM's Enhanced Graphics Adapter (EGA), most of which also emulate other common video adapters, were most prominent. New EGA offerings included a $269 card from PC's Limited (Austin, TX, (512) 339-6800), a $395 card from Tecmar (Solon, OH, (216) 349-0600), a $465 half-sized card from Intelligent Data Systems (Paramount, CA, (213) 633-5504), and a $499 card from Zenith Data Systems (Glenview, IL, (800) 842-9000). AST Research (Irvine, CA, (714) 863-1333) unveiled a card that furnishes an optional parallel port and costs $450 to $550, and Everex Systems (Fremont, CA, (415) 498-1111) introduced a $395 card that generates EGA and Hercules-type displays simultaneously on separate monitors. Orchid Technology (Fremont, CA, (415) 490-8586) exhibited a $945 card with an 80286 processor for increased speed. Also offering high speed is a card from Tseng Laboratories (Newtown, PA, (215) 968-0502); the card contains an on-board, proprietary VLSI graphics chip set.

New disk-drive offerings included a 100M-byte, full-height 5¼-in. drive and controller kit for internal mounting in IBM PCs and equivalent computers. The kit is from Priam Corp (San Jose, CA, (408) 946-4600). New "hard cards," 3.5-in. drives on plug-in controllers, debuted as well. Amba Inc (Santa Clara, CA, (408) 496-1000) introduced a 30M-byte unit (the price has not yet been fixed), and Western Digital (Irvine, CA, (714) 863-0533) introduced a 20M-byte unit for $895.

Two new half-card, 2400-baud modems appeared at Comdex also. Anchor Automation (Van Nuys, CA, (818) 997-7758) introduced a model for $499, and Novation Inc (Chatsworth, CA, (213) 996-5060) introduced a $595 unit.—Gary Legg

V.22 bis 2400-BPS MODEM PROVIDES PASSWORD PROTECTION

Operating with both American and CCITT telecomm protocols, the AJ-2412-AD3H stand-alone modem not only handles V.22 bis full-duplex 2400-bps transmission rates over dial-up phone lines, but also provides internal password protection to discourage unauthorized connections. The modem, from Anderson-Jacobson (San Jose, CA, (408) 435-8520), has an internal EEPROM that stores as many as twenty-five 43-digit telephone numbers and a modifiable connection password. Other features include automatic-repeat-request error correction, software programmability, internal diagnostics, automatic redial, and 8- to 11-bit character operation (synchronous or asynchronous). When configured with its complete complement of international hardware and software interface protocols, the modem sells for $595.—Denny Cormier

Z80 MANUFACTURER MARKETS COMPATIBLE HD64180

Zilog Inc (Campbell, CA), manufacturer of the Z80 8-bit μP, is now an alternate source for the Z80-compatible HD64180 μP from Hitachi Ltd (Tokyo, Japan). The HD64180 runs the same software as the Z80, including the CP/M operating system. It also incorporates features not found on the Z80, including an on-chip memory-management unit that addresses 256k bytes of memory — four times the amount of memory that the Z80 addresses. Zilog says its version — the Z64180 — will serve more highly integrated Z80-based designs. Hitachi will also give Zilog the design for an upgraded HD64180, which will be compatible with all Z80 peripheral devices. When it's available in the third quarter, the Z64180 will cost $14.50 (100).—David Smith

NEWS BREAKS

SPREADSHEET HANDLES DATA ACQUISITION FOR IBM PC ADD-INS

The RTSS, a memory-resident program from Data Motion (Orland Park, IL), provides software support for data-acquisition boards such as the Data Translation DT2801 Series and the Metrabyte Dash Series. You configure the I/O drivers and choose the acquisition parameters by "popping-up" the program with a special key combination. The program allows you either to monitor the data acquisition on the screen in real time or to acquire the data in background. You can manipulate the data by entering analysis formulas into the cells of the spreadsheet. The unprotected version of the program sells for $395; the protected version costs $345.—Margery Conner

16-BIT CMOS μC FURNISHES 240-nSEC CYCLE TIME

The HPC16040 16-bit μC, the first member of the HPC IC family from National Semiconductor (Santa Clara, CA, (408) 721-5000), uses a 17-MHz clock and features a CPU cycle time of only 240 nsec. It also includes six working 16-bit registers, optional on-chip 4k-byte code ROM, internal watchdog-timer logic, three 16-bit counter/timers, 16×16-bit multiply/divide instructions, a 38.4k-baud UART, and 52 general-purpose I/O lines. Fabricated with National's 2-μm CMOS process, the device specs a typical operating supply current of 2 mA; an idle/halt mode requires no more than 25 μA. National supplies its industrial (−40 to +85°C) ROMless HPC16040R in a 68-pin PLCC for $29.90 in sample quantities. A military-temperature version of the part will be available soon.—Denny Cormier

1000-MIPS COMPUTER COMPRISES 65,536 PROCESSORS

By interconnecting 65,536 processors, the Connection Machine from Thinking Machines Corp (Cambridge, MA) operates at a sustained processing rate of 1000 MIPS and a peak processing rate of 7000 MIPS. A DEC VAX or Symbolics 9600 computer acts as a front-end processor for the Connection Machine. Suitable for text recognition, visual processing, and numeric computations, it executes commands written in either a dialect of C (*C) or a dialect of Lisp (*Lisp). When configured with 32M bytes of RAM, it costs $3 million; a system with 16,384 processors and 8M bytes of RAM costs only $1 million.—David Smith

ADVANCES IN GRAPHICS TECHNOLOGY HIGHLIGHT NCGA '86

At the recent National Computer Graphics Association '86 show in Anaheim, CA, attendees were treated to significant advances in various areas of graphics technology. Culler Scientific Systems Corp (Santa Barbara, CA, (805) 683-5631) has introduced an 18-MIPS personal supercomputer (PSC) that implements fine-grain parallelism. The PSC offers networked users access to the power required for computer-intensive simulation. Users of Sun workstations may add the PSC resource in a networked environment for $98,500. Culler plans to tie the PSC to the DEC VMS environment.

The GR-1105 color-graphics terminal from Seiko Instruments (Milpitas, CA, (408) 943-9100) offers 1024×780-pixel resolution on a 14-in. screen. Prices start at $4995, and standard configurations include peripheral and hard-copy interfaces. The terminals feature a 32k×32k-point coordinate space and 512 selectable colors. The GR-1105 executes 4500 ¼-in. vectors/sec from the display's list memory.

Seiko is also offering a digitizing tablet that features plug compatibility with the industry-standard Summagraphics Bit Pad Two. The tablet, called Screenplay, features a 200-point/in. sampling rate and 11×11-in. size. The $495 device specs 1000-lpi resolution and 0.010-in. accuracy.—Maury Wright

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CIRCLE NO 11

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NEWS BREAKS: INTERNATIONAL

EDITED BY GEORGE STUBBS

OKI TO SUSPEND COMPUTER SHIPMENTS TO TANDY

Because of declining profits resulting from the devalued dollar, Oki Electric Industry Co has decided to suspend shipments of personal computers to Tandy Corp. Tandy markets those 16-bit systems in the US as the Model 600. Oki also declares it will curtail shipments of its if800 Series computers to other markets to minimize the impact of the yen's gains against the dollar.

SURVEY FINDS 68020 IS MOST FAVORED 32-BIT μP IN JAPAN

Motorola's 68020 microprocessor is the most widely used 32-bit μP in Japan, according to survey results published in *Nikkei Datapro* magazine. Of the companies that have developed or are planning to develop systems that incorporate 32-bit microprocessors, 42.5% plan to use the Motorola device. Intel's 80386 placed second, with 21.2% of the companies using or planning to use the μP. National Semiconductor's 32032 came in third place at 2.4%, followed by Nippon Electric's V70 (1.6%).

The questionnaire was sent to 1014 companies; 364 of them sent replies. The most popular application of 32-bit microprocessors, according to the survey, is in image processing, followed by engineering workstations, robotics and N/C devices, and process controls.

MATSUSHITA GROUP TO BEGIN CUSTOM LSI BUSINESS IN US

The Matsushita Electric Group is planning to enter the US semiconductor market with a custom-LSI facility at Matsushita's Panasonic subsidiary in NJ. The design center should be completed within the year. Although the Matsushita Group is becoming a major semiconductor supplier in Japan, it began to exploit export markets later than other Japanese companies, and in contrast with those companies, it has no offshore semiconductor production facilities.

FUJITSU ENTERS ECL-GATE-ARRAY MARKET

The 3000-gate MB125000 and the 4500-gate MB128000 ECL gate arrays from Fujitsu feature gate-delay times of 220 psec (basic delay) and 500 psec (standard load). Fujitsu achieves the devices' high speed by using oxide-film isolation technology and a 1-μm design rule for emitter width. The development cost for the MB125000 was ¥6,500,000 ($37,143), and the unit price is $171 (1000). The development cost for the MB12800 was $51,528, and the unit price is $257. The turnaround time is eight weeks, and sales will begin next month.

IC DESIGN SERVICES AVAILABLE IN ASIA-PACIFIC AREA

Companies with offshore manufacturing facilities in the Far East can turn to Chartered-Telmos Pte Ltd (Singapore) for design and engineering support. This company, a joint venture between Chartered Electronics Industries Pte Ltd, based in Singapore, and Telmos Inc of Sunnyvale, CA, is providing IC design services in the Asia-Pacific region. Initial product lines available from Chartered-Telmos include the TMG6000 CMOS analog-digital array from Telmos and the SCX Series micro-CMOS gate array from National Semiconductor Corp. The design center is equipped with a Daisy CAE workstation and a Calma GDS-II system.

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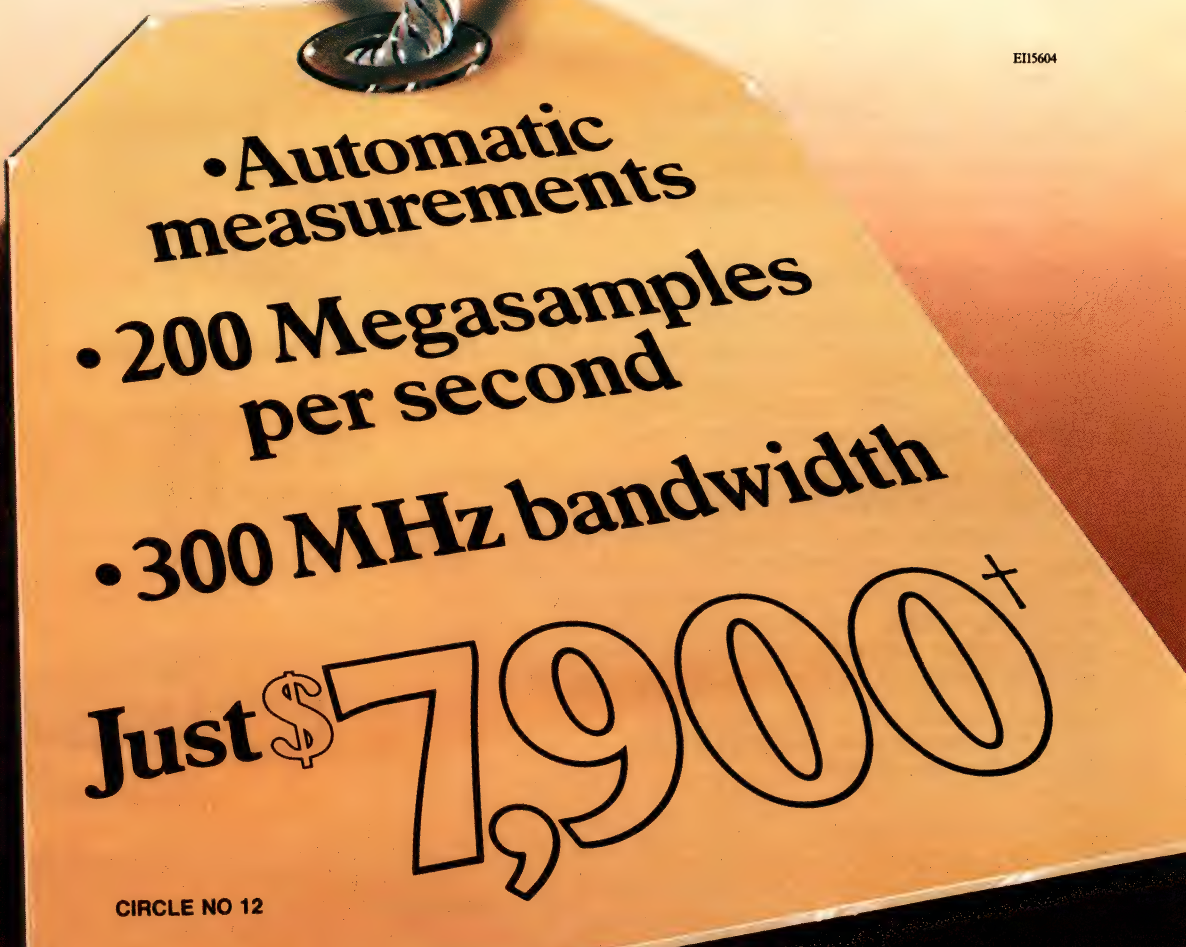

CIRCLE NO 12

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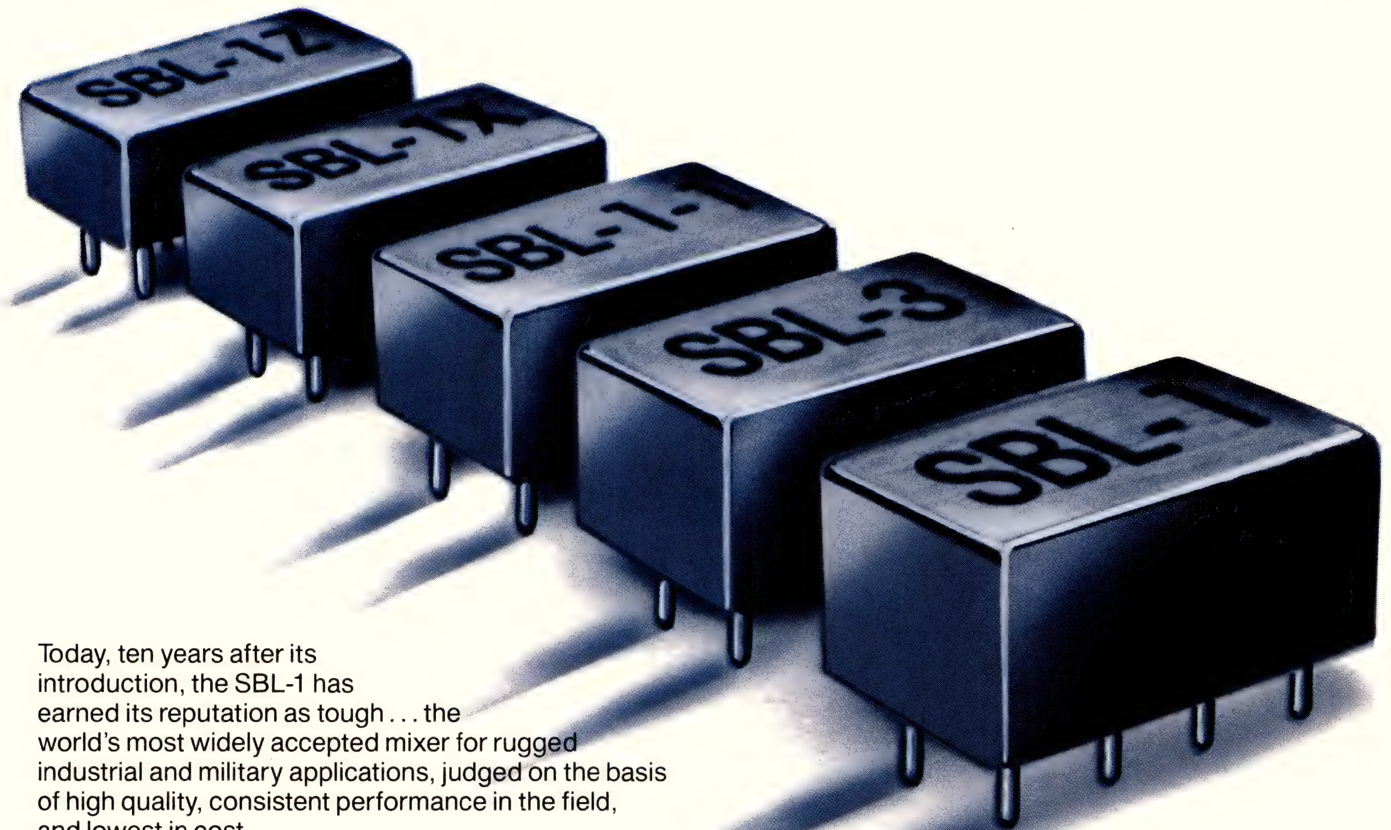

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* SBL-1X	10-1000	6.0	40	40	**$5.95**
SBL-1Z	10-1000	6.5	35	25	**$6.95**
SBL-1-1	0.1-400	5.5	35	40	**$6.50**
SBL-3	0.25-200	5.5	45	40	**$7.50**

* If not DC coupled.

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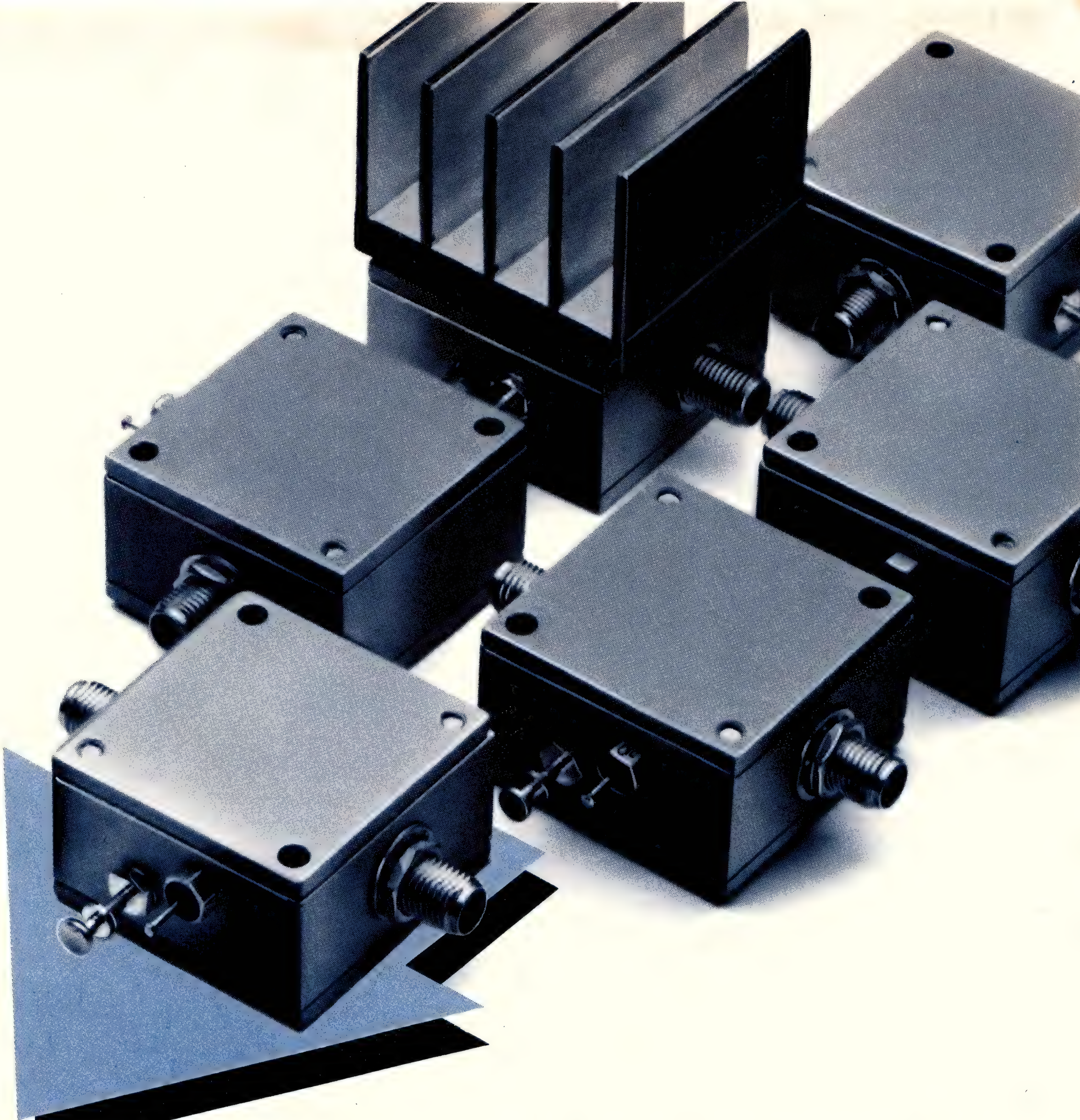

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Gain (dB), Min.	20	17	20	28
Gain Flatness (dB) Max.	±1.0	±1.5	±1.5	±1.0
Max. Power (dBm) (1dB compression)	+10	+3	+17*	+20
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3rd order Intercept pt (dBm)	+18	+13	+25	+33
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CIRCLE NO 15

C101 REV. A

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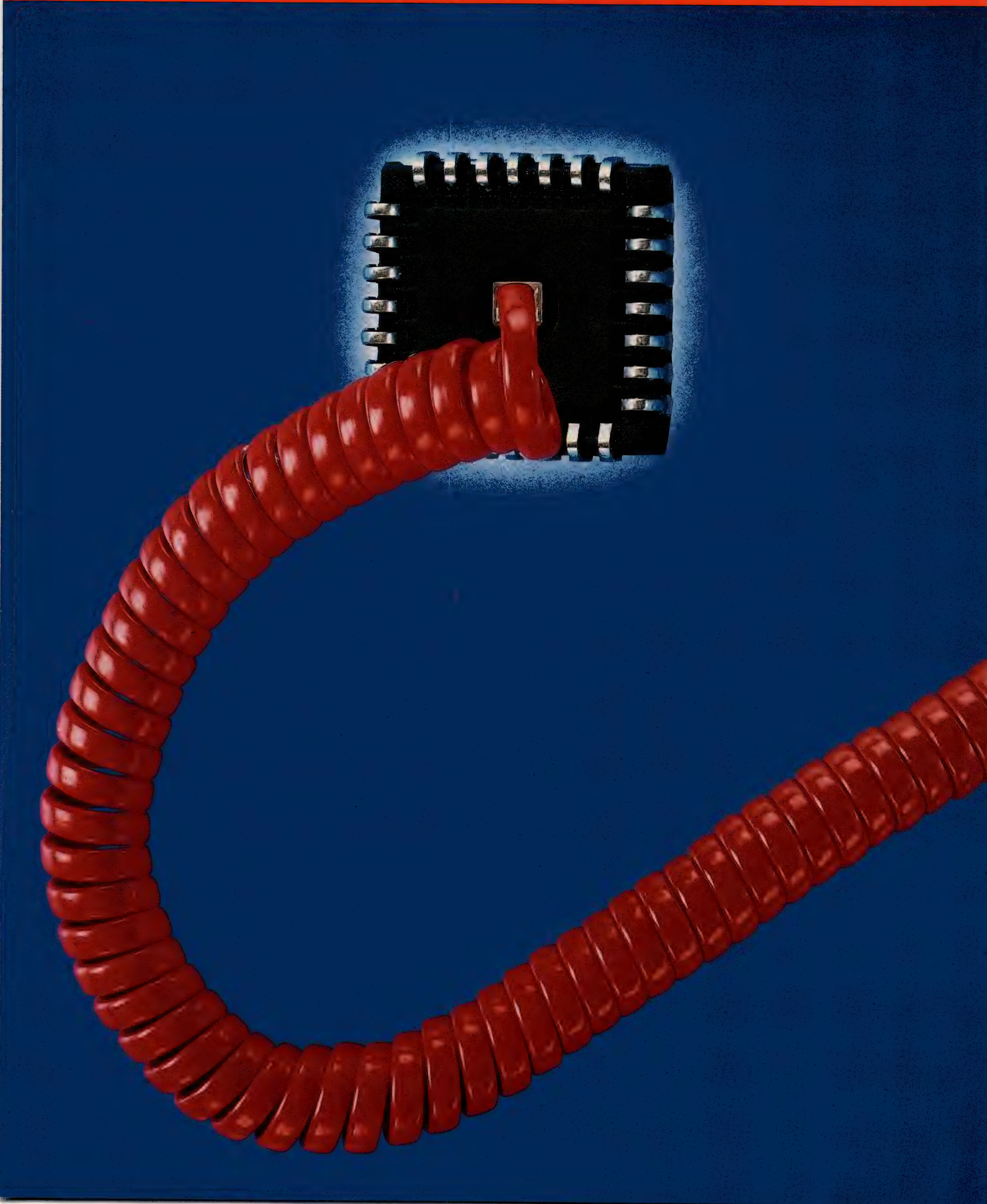
CIRCLE NO 16

Communications condensed:



the single-chip CMOS modem.

Introducing the K212, a complete Bell 212A compatible, full duplex modem on a single chip. It provides all the functions on one chip that used to require up to five separate chips.

Developed by Silicon Systems Inc., this 1200/300 bps modem is alternate sourced by RCA.

Peripheral-on-a-chip.

To the system designer, the K212 looks like a peripheral. It includes full Bell 103 and 212A operating modes, a call progress monitor and a DTMF dialer.

Interface with popular micros.

The K212 interfaces directly with the 8048/8051 family of low-cost micros. Modem operation is controlled through the on-chip, 8-bit multiplexed address and data bus, or through an optional serial-command bus. The address-latch-enable control line simplifies address demultiplexing. Data communications go only through a separate serial port.

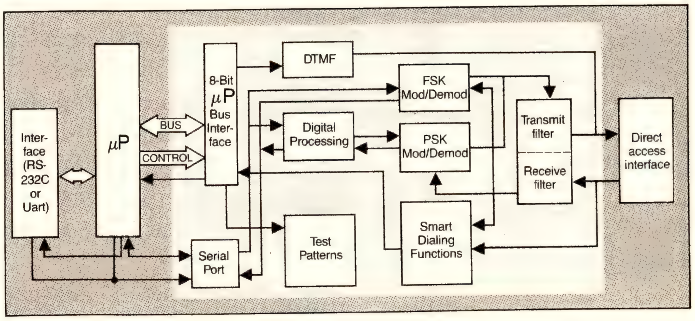
The on-chip DTMF enables the K212 to dial its own calls. And a call-progress detection feature allows it to change calling action in response to dial tones, busy signals or ring back. The dial-up phone line is connected through an external direct access arrangement interface (FCC approved).

And because it's CMOS, the K212 consumes very little power (less than 10mW in the idle mode and only 120mW in operation).

*8048 and 8051 are trademarks of Intel Corporation.

It makes talk even cheaper.

Now a complete modem requires only the K212, a phone line interface, an RS-232-C level converter and a control microprocessor. Perfect for personal computer modems,



voice/data terminals, portables or battery operated systems. Ideal for free-standing products or systems; synchronous or asynchronous communications.

By eliminating multi-chip sets, you save board space, testing and time in bringing your product to market.

Futurespeak: the V.22 modem.

The K221 modem is coming soon, to support CCITT V.22 and V.21 communications protocol standards for Europe.

Availability: lines are open now.

You can get the K212 in 22-pin and 28-pin DIPs, or in quad packages. Samples are available for evaluation right now.

To order samples, write: RCA Solid State, Box 2900, Somerville, NJ 08876, or Silicon Systems, 14351 Myford Road, Tustin, CA 92680.

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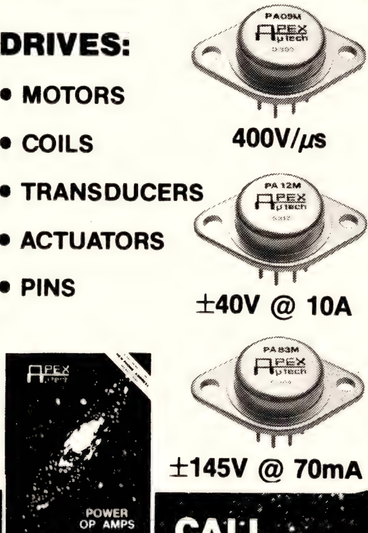

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CIRCLE NO 18

SIGNALS & NOISE

Instrumentation amp offers good dc CMRR

Dear Editor:

I read with interest Mr Graeme's Design Idea, "Use dual op amp in an instrumentation amp" (EDN, February 20, pg 241). As I had an immediate application for his circuit, I built it.

In evaluating the circuit's performance, I noticed that the dc CMRR seemed significantly better than Mr Graeme predicted (he predicted that it would be inversely proportional to the mismatches of resistors R). Using several different batches of 1% resistors for R, and with R_G set for a circuit gain of 40 dB, I typically obtained a dc CMRR of −80 dB, where −40 dB (for 1% mismatches) would have been expected.

When I analyzed the circuit, I came to the conclusion that the dc CMRR is inversely proportional to the product of the circuit gain and the mismatches of the resistors R. This conclusion would correlate well with my experimental results and would indicate that CMRR is not limited to the precision of the resistors used; instead, it's improved beyond that point by a factor equal to the circuit gain.

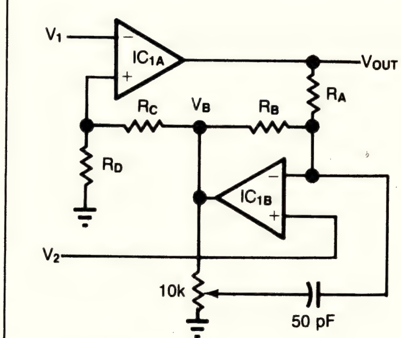
The strategy of increasing gain is not without peril, however. Mr Graeme notes that IC_{1B}'s output has a wider swing than V_{OUT}. You can solve this problem by going from a 5-resistor circuit to the 4-resistor circuit shown in the accompanying figure. In this circuit, IC_{1B}'s output voltage is $GV_1/(G-1)$ (where G is the circuit gain), which virtually eliminates the possibility that IC_{1B} could clip before V_{OUT} does. The excellent dc CMRR of Mr Graeme's circuit is not lost here, even though two different pairs of differently valued resistors are used. The dc CMRR is roughly equal to

$$\left|\frac{R_B}{R_A}-\frac{R_C}{R_D}\right|.$$

Once again, 1% resistors can be expected to produce a CMRR of almost −80 dB for a gain of 40 dB.

Finally, as Mr Graeme notes, the ac CMRR does degrade with increasing frequency. This degradation is not due to the unequal feedback factors of the op amps, but to the noninfinite gain of IC_{1B}. The ac CMRR can still be improved with the circuit he suggests, which consists of the pot and the capacitor. Using it, I was able to reduce a 10-kHz CMRR of −55 dB to −90 dB.

Sincerely yours,
Christopher Paul
Coherent Communications
Hauppauge, NY



NOTES:
1. SET $R_A=R_D$ AND $R_C=R_B$
2. $G=1+R_A/R_B=1+R_D/R_C$
3. $V_{OUT}=G(V_2-V_1)$
4. $V_B=[G/(G-1)]V_1$

Plug-in module manipulates hex numbers

Dear Editor:

A number of Design Ideas that have appeared in EDN have been concerned with using the HP41-C calculator as a design aid for manipulating hexadecimal numbers. HP does, in fact, manufacture a plug-in module (the HP-IL 41-15043 development module) that performs many of the functions required by the design engineer. These Boolean functions include hexadecimal, octal, and binary representations,

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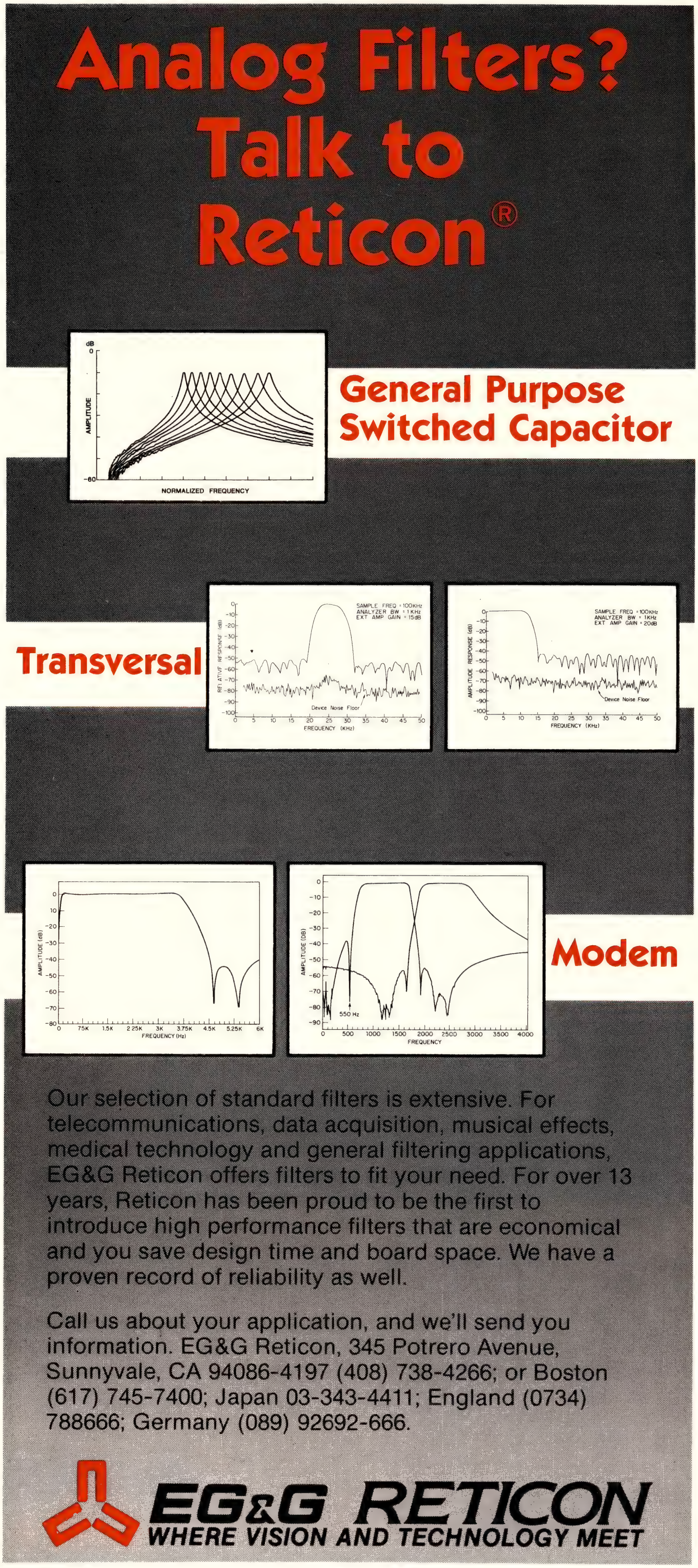

CIRCLE NO 20

together with AND, OR, NOR, XOR, Rotate (ROTXY), and bit-testing (BIT?) functions. I find the module quite invaluable and feel it should stem the flow of hex programs for the HP41-C.

Sincerely yours,
Allen Brown
Fibre Gyro Group
British Aerospace
Stevenage, Herts, UK

Correction

EDN's Semicustom-array directory (March 6, pg 96) incorrectly listed Matra Design Systems' address as Los Gatos, CA. The correct address is 2840 San Tomas Expressway, Santa Clara, CA 95051. Phone (408) 986-9000.

YOUR TURN

EDN's Signals and Noise column provides a forum for readers to express their opinions on issues raised in the magazine's articles or on any topic that affects the engineering industry. Send your letters to the Signals and Noise Editor, 275 Washington St, Newton, MA 02158. We welcome all comments, pro or con. All letters must be signed, but we will withhold your name upon request. We reserve the right to edit letters for space and clarity.

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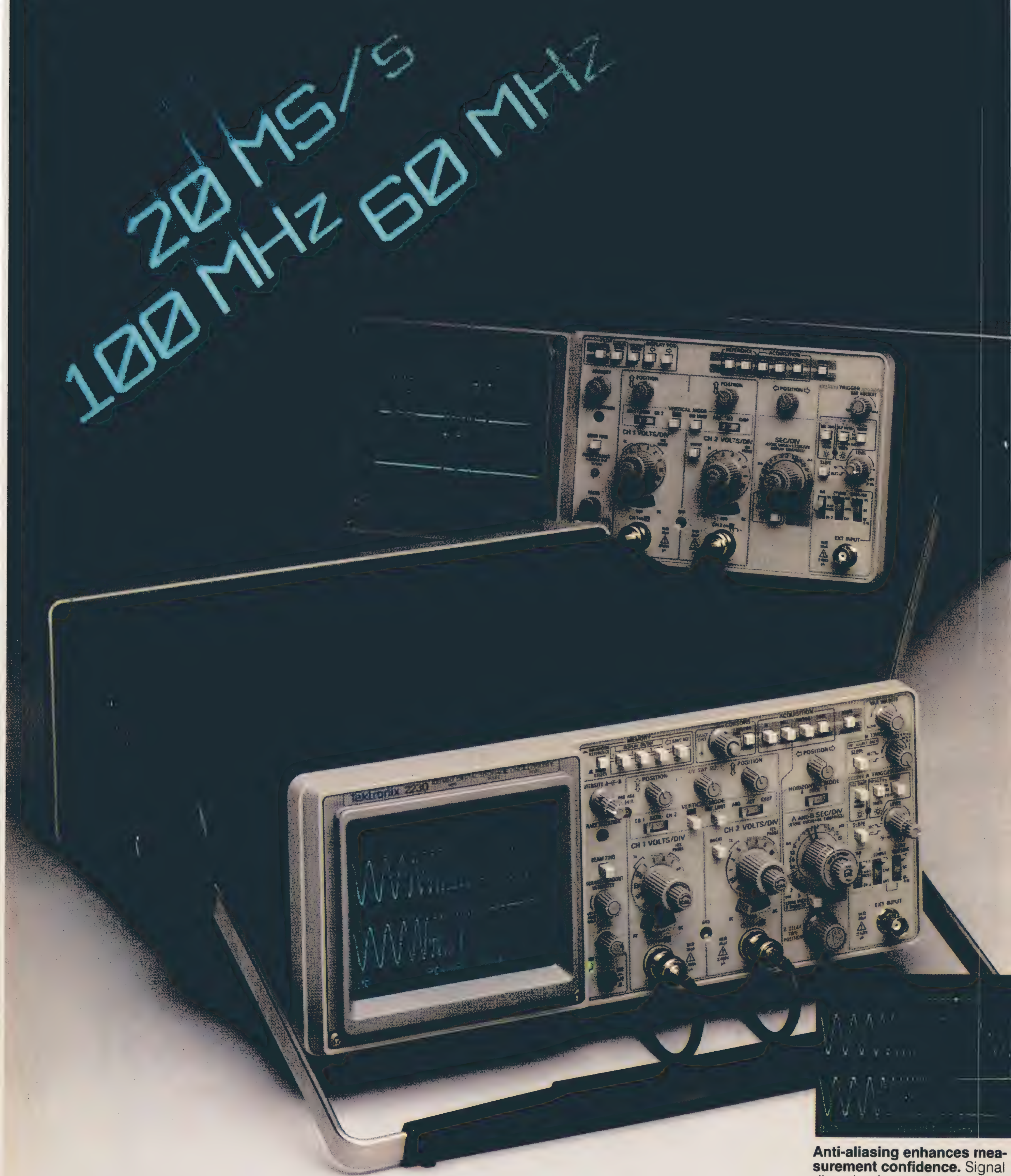

Anti-aliasing enhances measurement confidence. Signal distortion (sample mode only) is shown at high frequencies (top). The peak detect mode displays peak information without signal distortion (bottom).

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Enhancing use of the scopes as design and troubleshooting tools are fast sample and hold detector circuits, plus the proprietary peak detect mode. They enable the display of pulses as narrow as 100 ns at any sweep speed—even on a single sweep.

You'll also find such features as post-acquisition expansion and compression, X-Y capability to each scope's storage bandwidth and, for systems use, optional GPIB or RS-232-C interfaces.

Best of all, the 2220 and 2230 are easy to use and afford. And backed by Tek's famous 3-year warranty that includes the CRT. Check the front panels. The controls are familiar, comfortable, easy to identify. Designed to push productivity and minimize training time.

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Features	2230	2220
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Single Shot (Transient) B.W. (10 points per signal period)	2 MHz	2 MHz
Maximum Sampling Speed	20 MS/s	20 MS/s
Record Length	4K/1K (selectable)	4K
Save Reference Memory	One, 4K Three, 1K	One, 4K
Vertical Resolution	8 bit 10 bit (avg mode)	8 bit
Peak Detect	Yes (100 ns)	Yes (100 ns)
Averaging	Yes (menu-selectable)	Yes (rep. sampling)
X-Y Storage Bandwidth	100 MHz	60 MHz
GPIB/RS-232-C Options	Yes (talker/listener, includes 26K of battery-backed memory)	Yes (talker/listener)
Price	$5150	$4150

Get the reliability and performance you expect in Tek scopes, now enhanced by digital storage, at unexpected prices: $4150 for the 2220, $5150 for the 2230.

For the full story, and more impressive numbers, contact your local Tek Sales Representative today. Or call the Tek National Marketing Center,

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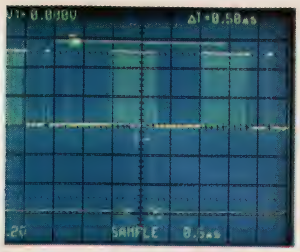
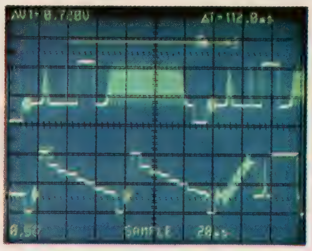
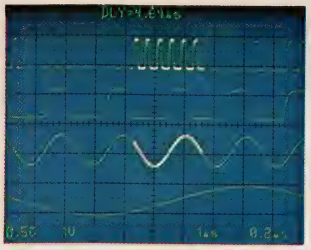


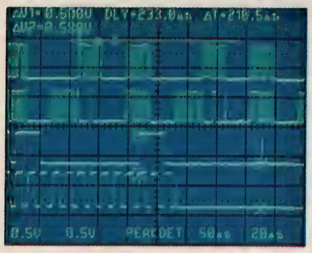
n-screen viewability lets you ‹pand, compress, and position aveforms saved in reference emory. This permits easy viewg and display flexibility of up eight saved waveforms.



High display resolution and accuracy permits on-screen viewing of signals such as the TV test signal shown here. 4K of record information can be viewed in 1K windows.



100 MHz, non-storage capability comes standard in the 2230. In addition, there's dual channel, dual timebase, versatile triggering and CRT readout.



The 2230 offers the convenience of CRT readout in both storage and non-storage modes at 100 MHz. Storage mode cursors make ΔV, ΔT, and 1/ΔT measurements fast and easy.

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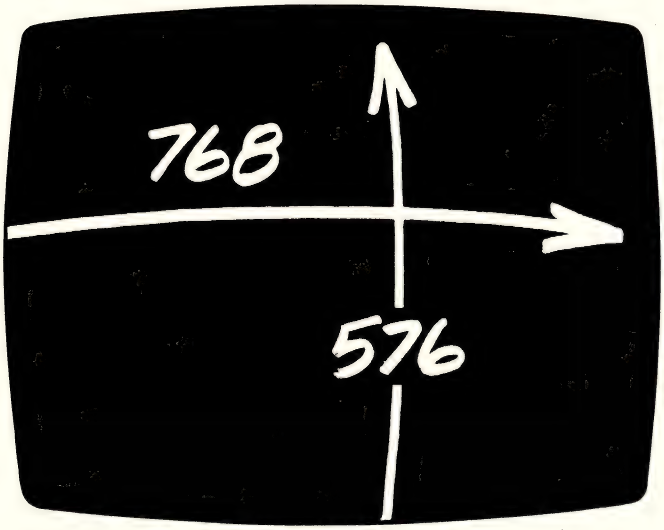
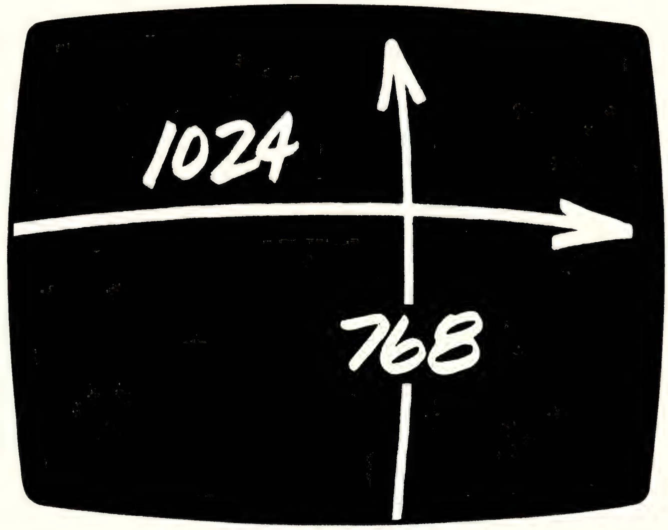
Introducing four positutely



PERSONAL COMPUTER GRAPHICS



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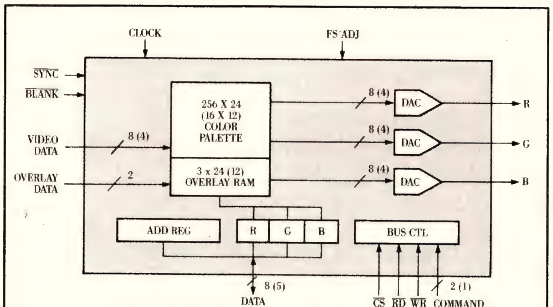
Our new family of RAMDACs is bound to make a Brooktree convert out of you.

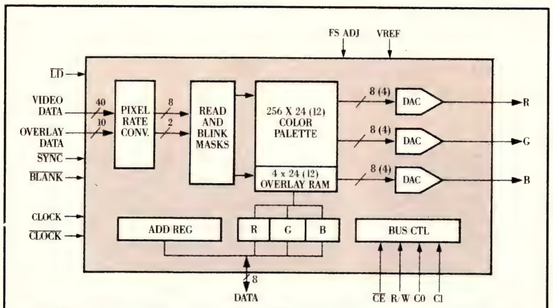
Who gives a duck's tail about RAMDACs, anyway?

Apparently, none of our competitors. None has chosen to produce more than one RAMDAC. None, we believe, has taken the time or effort to design even *one* RAMDAC the right way. The Brooktree Way.

We, on the other hand are now introducing four new RAMDACs—high performance D-to-A circuits with built-in color palettes. They make it easier than ever for you to achieve your new year's resolutions, no matter what type of graphics system you're designing. And they all take advantage of our revolutionary low-glitch architecture.



Bt453 Triple 8-bit 40 MHz RAMDAC/Bt450 Triple 4-bit 70 MHz RAMDAC



Bt458 Triple 8-bit 125 MHz RAMDAC/Bt451 Triple 4-bit 125 MHz RAMDAC

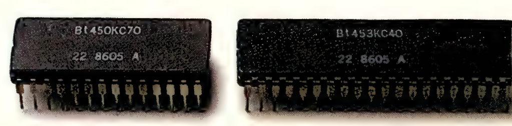
Ask about our Sidecar RAM.™

Here's a vivid example of our commitment to elegant design: Each of our four new RAMDACs includes two overlay ports that address a separate color palette. This makes cursors, menus, alphanumeric overlays, etc. easier to handle.

Because this Sidecar RAM, as we call it, stores the colors for these overlay options, all the colors in the color palette RAM can be used to display rendered images.

Ask about our Triple 4-bit RAMDAC.

Our Bt450 is a 70 MHz, 16-color palette, Triple 4-bit



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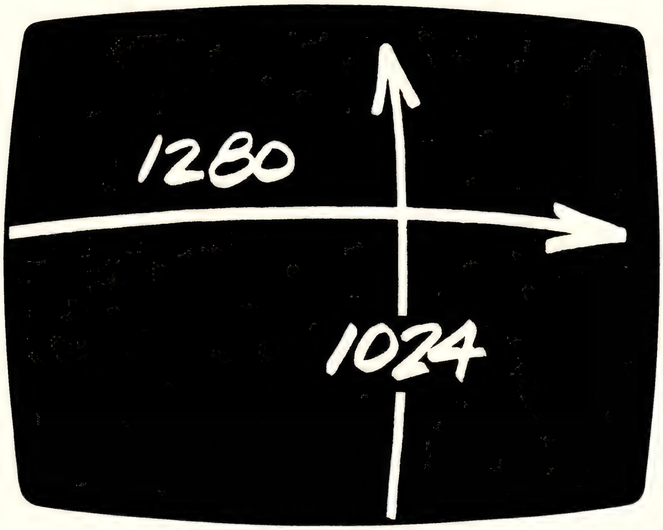
resolutionary RAMDACs.



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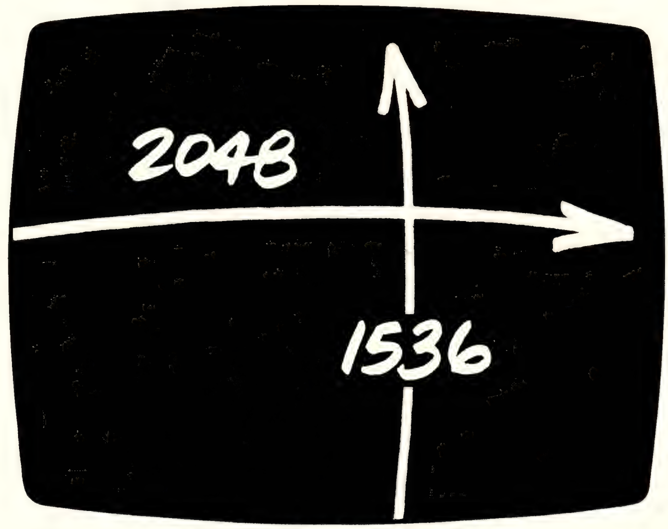

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RAMDAC—in a single monolithic CMOS chip.

Compare it to the TMS34070. It has a voltage output. Ours has an adjustable current output that drives doubly-terminated 75-ohm coax directly. Their part doesn't.

Our color palette is fully dual ported. Not theirs.

Ours is RS-343-A compatible, including SYNC tip and blanking pedestal. Theirs isn't.

Most important, the Bt450's overlay RAM and separate MPU port makes your design job a lot easier.

Ask about our Triple 8-bit RAMDAC.

Our Bt453 is a 40 MHz, 256-color palette, Triple 8-bit RAMDAC—also in a single monolithic CMOS chip.

Frankly, it's not even fair to compare it to the IMSG170. It's six bits. Ours is eight.

So only Brooktree can give you, simultaneously, 256 colors out of a 16.8 million-color palette. That means you can do solids modeling without color compromise.

Who can you ask about our 125 MHz RAMDACs?

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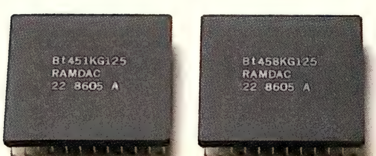
Our Bt451 is a 125 MHz 256-color palette, Triple 4-bit RAMDAC. The Bt458 is a pin-compatible 8-bit version. Also 125 MHz. Both TTL-compatible. *Not* ECL.



And because they're pin compatible, you can design one system that can be switched from 4-bit to 8-bit DAC resolution by exchanging just one chip.

Just look at these features: On-chip 4:1 and 5:1 Pixel Rate Converter, direct interface to frame buffer RAM, separate MPU interface, blink/blank registers and fully dual-ported RAM cells.

Gee, do you think we should build a 250 MHz version, too?

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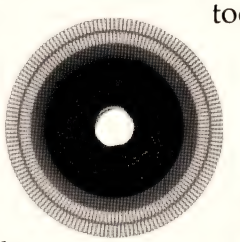

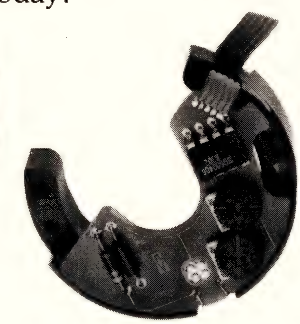

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DID YOU KNOW?

Half of all EDN's articles are staff-written.

EDN

CALENDAR

EMC Expo '86, Washington, DC. EMC Expo, 101½ S Union St, Alexandria, VA 22065. (703) 548-2802. June 16 to 19.

NCC (National Computer Conference), Las Vegas, NV. AFIPS, 1899 Preston White Dr, Reston, VA 22091. (703) 620-8900. June 16 to 19.

Modern Power Conversion Design Techniques (short course), San Diego, CA. E/J Bloom Associates, 115 Duran Dr, San Rafael, CA 94903. (415) 492-8443. June 16 to 20.

Robotic End Effectors: Design and Applications (seminar), Detroit, MI. Society of Manufacturing Engineers, Box 930, Dearborn, MI 48121. (313) 271-1500, ext 392. June 17 to 18.

Local Area Networks (short course), Chicago, IL. Center for Advanced Professional Education, 1820 E Garry St, Suite 110, Santa Ana, CA 92705. (714) 261-0240. June 18 to 20.

International Conference on Communications '86, Toronto, Canada. IEEE Communications Society, 1450 Don Mills Rd, Don Mills, Ontario, Canada, M3B 2X7. (416) 445-6641. June 22 to 25.

Society of Women Engineers National Convention, Hartford, CT. Society of Women Engineers, 345 E 47th St, New York, NY 10017. (212) 705-7855. June 22 to 29.

ATE East, Boston, MA. Morgan-Grampian Expositions Group, 1050 Commonwealth Ave, Boston, MA 02215. (800) 223-7126; in MA, (617) 232-3976. June 23 to 26.

Effective Use of In-Circuit and Functional Testing (short course), Milwaukee, WI. Center for Continuing Engineering Education, University of Wisconsin-Milwaukee, 929 N 6th St, Milwaukee, WI 53203. (414) 224-3952. June 23 to 25.

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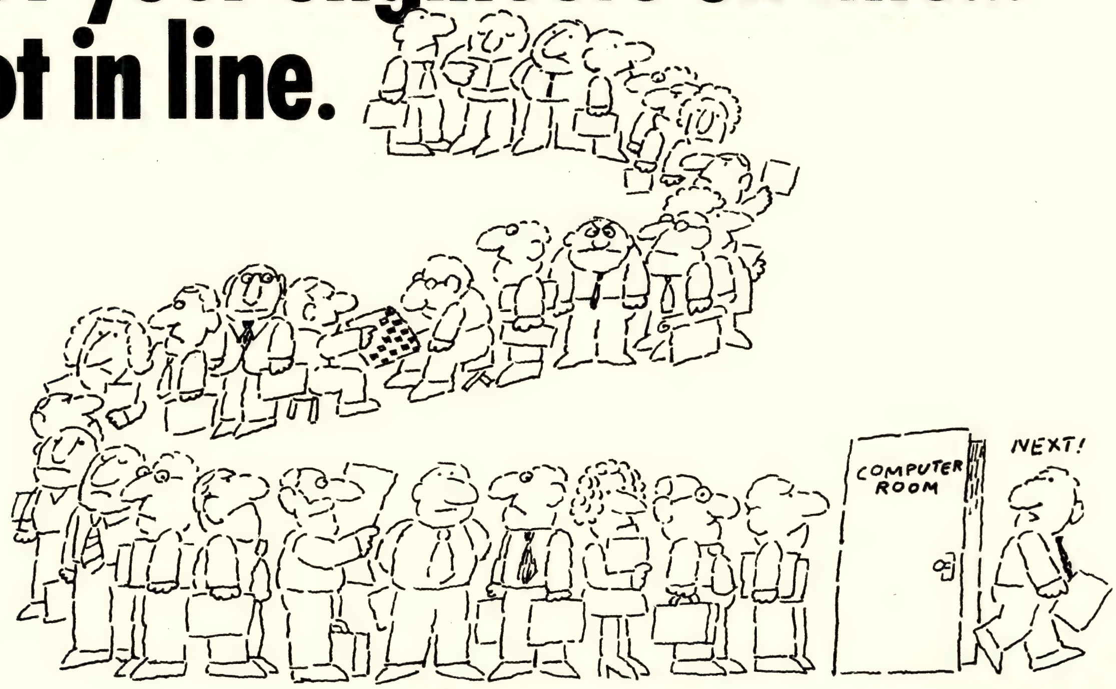
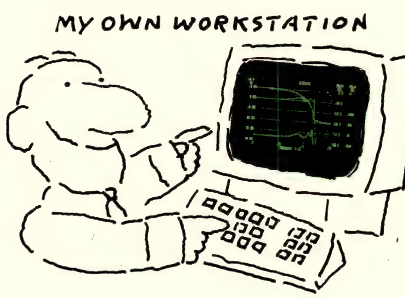
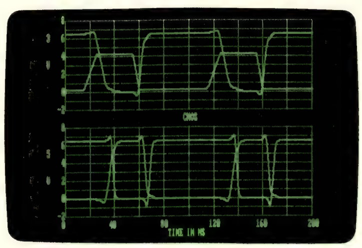
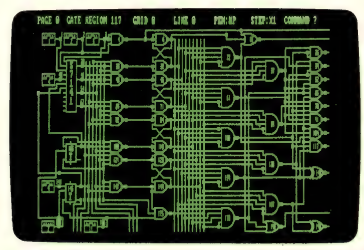





"Typical MICROCAP Transient Analysis"


"Typical MICROLOGIC Diagram"

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MICROCAP: Your Analog Solution

MICROCAP is an interactive analog circuit drawing and simulation system. It allows you to sketch a circuit diagram right on the CRT screen, then run an AC, DC, or Transient analysis. While providing you with libraries for defined models of bipolar and MOS devices, Opamps, transformers, diodes, and much more, MICROCAP also includes features not even found in SPICE.

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MICROLOGIC provides you with a similar interactive drawing and analysis environment for digital work. Using standard PC hardware, you can create logic diagrams of up to 9 pages with each containing up to 200 gates. The system automatically creates the netlist required for a timing simulation and will handle networks of up to 1800 gates. It provides you with libraries for 36 user-defined basic gate types, 36 data channels of 256 bits each, 10 user-defined clock waveforms, and up to 50 macros in each network. MICROLOGIC produces high-resolution timing diagrams showing selected waveforms and associated delays, glitches, and spikes—just like the real thing.

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Regarding MICROCAP . . . "A highly recommended analog design program" (PC Tech Journal 3/84). "A valuable tool for circuit designers" (Personal Software Magazine 11/83).

Regarding MICROLOGIC . . . "An efficient design system that does what it is supposed to do at a reasonable price" (Byte 4/84).

MICROCAP and MICROLOGIC are available for the Apple II (64k), IBM PC (128k), and HP-150 computers and priced at $475 and $450 respectively. Demo versions are available for $75.

MICROCAP II is available for the Macintosh, IBM PC (256k), and HP-150 systems and is priced at $895. Demo versions are available for $100.

Demo prices are credited to the purchase price of the actual system.

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CIRCLE NO 25

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CIRCLE NO 26

CALENDAR

EFOC/LAN '86 (European Fiber Optic Communications and Local Area Networks Exposition), Amsterdam, Holland. In US, contact Information Gatekeepers, 214 Harvard Ave, Boston, MA 02134; (617) 232-3111. In Europe, contact IGI Europe, c/o AKM, Box 6, 4005 Basel, Switzerland; 061-50-88-66. June 23 to 27.

AutoCAD Expo '86, Chicago, IL. Peggy Steffens, Autodesk, 2320 Marinship Way, Sausalito, CA 94965. (415) 332-2344, ext 703. June 24 to 26.

International Aerospace and Ground Conference on Lightning and Static Electricity, Dayton, OH. Larry Walko, US Air Force, AFWAL/FIESL, Wright-Patterson Air Force Base, OH 45433. (513) 257-7718. June 24 to 26.

ACM/IEEE Design Automation Conference, Las Vegas, NV. MP Associates, 7366 Old Mill, Suite 101, Boulder, CO 80301. (303) 530-4333. June 29 to July 2.

Semicon/Osaka '86, Osaka, Japan. Semiconductor Equipment and Materials Institute, 625 Ellis St, Suite 212, Mountain View, CA 94043. (415) 964-5111. July 1 to 3.

IEEE Compass '86 (Computer Assurance—Systems Integrity: Process Security and Safety), Washington, DC. Albert Friend, IEEE Compass, Box 3815, Gaithersburg, MD 20878. July 7 to 11.

Effective Implementation of Surface Mount Technology (short course), Milwaukee, WI. Center for Continuing Engineering Education, College of Engineering and Applied Science, 929 N 6th St, Milwaukee, WI 53203. (414) 224-3952. July 14 to 16.

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CIRCLE NO 27

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High performance in analog design requires careful attention to a hundred details. There are so many things that can cause your system to fail. Each resistor or capacitor, even a length of wire, can significantly alter the system specs.

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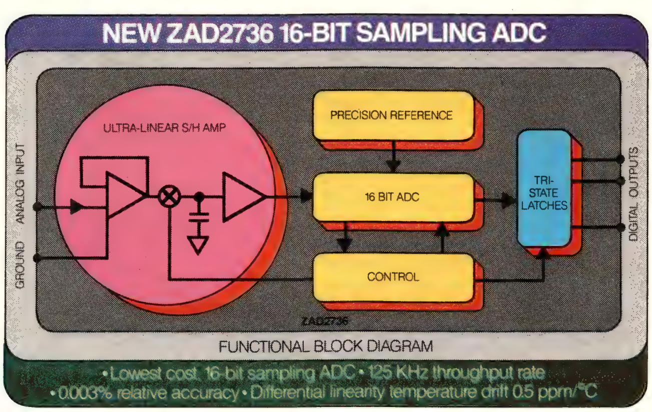

CIRCLE NO 28

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64K CMOS SRAMs

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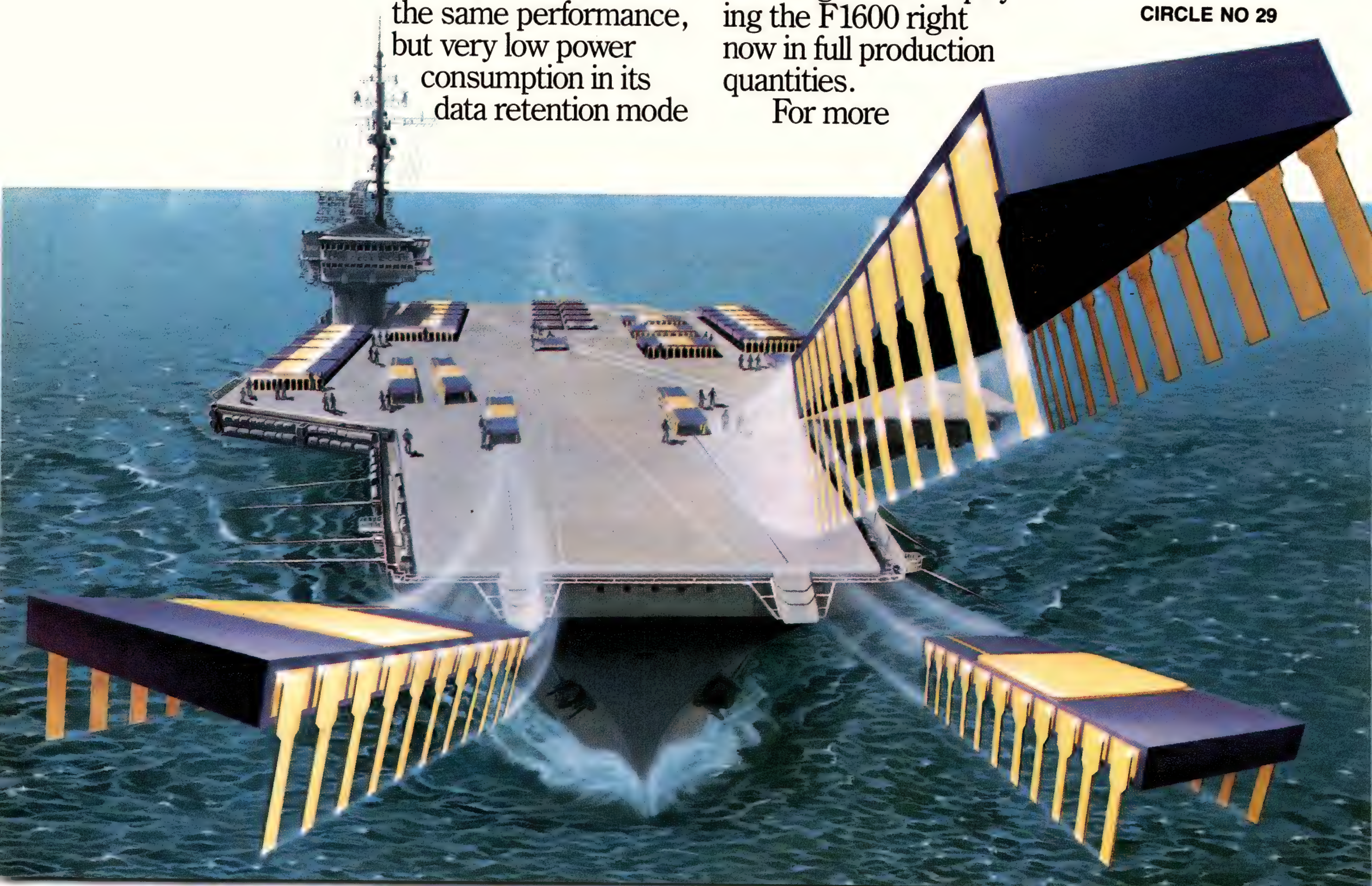

EDITORIAL

Special Issues: Holistic Technology

Most issues of EDN strive for breadth of coverage—each such issue runs the gamut of electronics technology with its variety of staff-written articles and its features that you and your colleagues have contributed.

But each year, EDN publishes several special issues that concentrate on specific topics: Our April 3 issue, for example, focused on communications technology, this issue is devoted to analog technology, and the next one will concentrate on digital technology.

The analog and digital issues are often accompanied by editorials and letters to the editor that tout or bemoan—facetiously or seriously—the demise or ascendancy of analog or digital technology. But what strikes us this year is the increasing difficulty of identifying "analog" and "digital" articles to include in these issues. Consider, for example, "Digital gain control streamlines signal-acquisition systems," on pg 171. That article, which discusses a monolithic op amp that features digitally programmable gain, defies pigeonholing.

Our special reports for these two issues further illustrate the problem: This issue's report discusses data converters; next issue's lists analog I/O boards for the IBM PC. Each of these reports emphasizes how easy it's becoming to move from one domain to the other and implies the increasing probability that your designs will involve both worlds.

The merging of analog and digital technologies extends from semiconductor fabrication through system design. For example, as our cover photo illustrates, manufacturers are combining digital-CMOS and analog-bipolar technologies on one chip. And next issue's cover story will discuss the hardware and software factors to consider when you design a system that acquires analog signals for digital analysis.

The trend toward combining the analog and digital worlds is apparent not only in components and subassemblies, but in design tools. For example, as the technology update beginning on pg 49 notes, CAE vendors are incorporating analog design software in their digital design packages.

Because the line dividing analog designs from digital ones has blurred, you'll find that proficiency in both analog and digital design techniques will become increasingly valuable.

Rick Nelson

Rick Nelson
Managing Editor

Get on top of your market

with NEC's new 8-bit CMOS single-chip real-time microcontroller.

Now there's an 8-bit microcontroller that rivals 16-bit speed and power. And gives you a single-chip solution for control applications that used to require multi-chip micros.

The μPD78312 is the spearhead of NEC's enhanced 78000 Series of 8-bit CMOS single-chip microcomputers. It replaces multi-chip devices in a wide range of applications. Including high-speed printers, facsimiles and copiers. As well as industrial robots and cars.

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You get a host of advanced features on the function-packed μPD78312. Including a 16-bit CPU with a powerful instruction set, enhanced interrupt capability, and a high-speed high-precision AD converter. Everything you need for real-time control of motors and engines.

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0.5μs cycle time.
16×16-bit multiply in 3.2μs.
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It also features 8K bytes of on-chip ROM and 256 bytes of RAM. You can directly address up to 64K bytes of external ROM or RAM. EPROM and ROM-less versions are also available.

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- ☐ One-byte call instruction

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NEC

CIRCLE NO 30

DAISY IS ENGINEERING

BULLETIN:

ANALOG SOLUTIONS

Analog: Major commercial commitment now yielding advanced design tools.

The first product of Daisy's recently formed Analog Design Division was introduced at the June, 1985 DAC. Daisy's fully commercialized SPICE (DSPICE™) and the new Daisy Analog Libraries™ represent the first results of an unprecedented industry commitment to analog solutions. Daisy's open system architecture, DNIX™, allows the full integration of the Analog Design Series into the CAE environment.

User interface: Graphic driven, interactive; sets new productivity standards.

DSPICE features a multi-window, icon-oriented graphics environment so the user can interactively select design portions from the schematic and initiate simulation runs without recompiling, with simulation results displayed in real time. Or the user can interrupt at any time, modify the design 'on the fly', and resimulate. In the interactive, *iterative* design process, this enhanced, 'intuitive speed' capability shortens the experience curve of building and understanding complex circuits.

Enhanced, supported simulator: Convergence *solved.*

When a SPICE analysis fails to resolve (or *converge*) all the variables in the design, the simulation fails. This has proven a significant hindrance to the productivity potential of other SPICE simulators. Important among the many DSPICE enhancements is the elimination of this failure to converge. In hundreds of DSPICE benchmarks to date, *convergence is 100%.*

Analog libraries: "Virtual" analog breadboarding for the systems designer.

Creating a 'turnkey' analog simulator for the systems designer requires extensive, *accurate* libraries of discrete components and analog ICs. Daisy's Analog Library is growing *rapidly* to encompass the greater part of the discrete and analog IC component universe. Key to the growth is a tool set for automatic characterization of discrete components, and a breakthrough in accurate, 'black-box' macro-modeling of analog integrated circuits. These same library building tools are available to *users*, allowing them to extend the libraries to their own proprietary needs easily.

Daisy Literature Hotline: 1-800-556-6661 1-800-824-2385 in CA Department D29.

For information on Daisy's growing Analog Design Series, and on the entire Daisy CAE product line, call the Daisy Literature Hotline at 1-800-556-6661 (in California, 1-800-824-2385) and ask for Department D29. Or write the Daisy Literature Hotline at 3606 W. Bayshore, Palo Alto, California, 94303.

Trademarks: Daisy, Daisy Analog Libraries, DNIX, DSPICE—Daisy Systems Corp.

Tester mockups and device libraries bring CAE to analog pc-board design

Eva Freeman, *Associate Editor*

Design-automation tools for analog pc boards have advanced well beyond straightforward interfaces to the Spice circuit simulator. To help you model analog designs accurately, CAE vendors such as Valid and Analog Design Tools have expanded the capabilities of their analog-design software and made the software easier to use. In addition, a number of vendors have extended their libraries of standard analog parts. What's more, CAD companies haven't forgotten that circuit design doesn't end with a sheet of paper; systems like Zuken's Analog Designer include special features just for analog board layout.

A group at the University of California at Berkeley developed Spice (simulation program with integrated circuits emphasis), the fundamental program of circuit simulation, and continues to maintain it. Spice evaluates circuits at the transistor level and performs ac, dc, transient, Fourier, and worst-case analyses. Until recently, the only way to simulate an analog design was to run Spice, generally in a batch mode, on a computer at least as powerful as a VAX 11/780.

Fig 1—When a mock function generator *applies a stimulus to the cascode-amplifier design shown here, Valid's Analog Designer displays the response of the circuit on a simulated voltmeter and oscilloscope.*

Software models your bench top

Although Spice models analog circuits completely, the program isn't easy to operate. To use Spice, you must know how to create a set of test vectors and interpret the results of your simulation. You also must define a simulation library that describes your analog parts. Fortunately, you don't have to learn how to use Spice or generate a simulation library anymore; CAE packages are available that simplify the use of Spice and that include extensive device libraries.

Two analog CAE packages, Analog Design Tools' Analog Workbench and Valid Logic's Analog Designer, feature on-screen menus that let you control simulations easily. Instead of defining a set of test vectors, you control simulations on the Analog Workbench and the Analog Designer by defining the setups of mock test instruments.

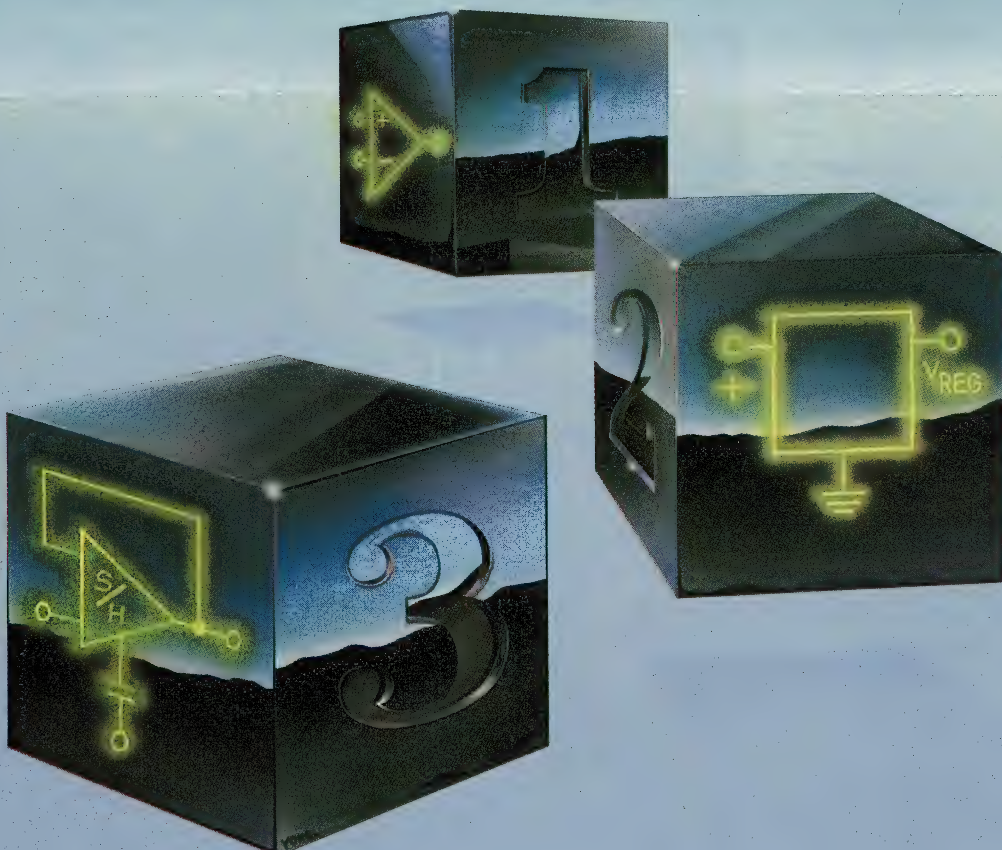
The mock test instruments in Valid's $79,500 Analog Designer comprise a function generator, an oscilloscope, a voltmeter, and a network analyzer. The function generator provides the stimulus to your circuit; the oscilloscope and the voltmeter display the response of your circuit to the stimulus. You can use the network analyzer to measure the phase and gain of your circuit's nodes as a function of frequency (for frequencies as high as 200 MHz).

In **Fig 1,** you can see how the Analog Designer simulates a cascode amplifier. In this screen shot, the function generator is outside the toolbox window, which indicates that the mock instrument is applying a signal to the amplifier. Colored nodes indicate the placement of probes; the colors of the output waveforms correspond to the schematic-node colors.

Spice is the main ingredient

ValidSpice, the vendor's implementation of Spice, accepts inputs from the simulated test instruments and determines their output. Ac-

Analog Semicustom Design... It's never been easier.



Ferranti Interdesign opens a new dimension to system level designers of analog circuits. Now you can enjoy the benefits of cost and size reductions by designing directly onto silicon. It's never been easier. Never faster.

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Macrochip™ is a new analog semicustom IC design system that you can use on your Mentor workstation, IBM AT/XT or Analog Workbench. Predesigned and characterized analog building blocks such as op amps, comparators, and timers can be called up from the Macrochip library. Connect them together with active and passive components from the library and verify the design instantly at your own display terminal.

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CIRCLE NO 31

cording to the vendor, ValidSpice (running on a floating-point coprocessor board) can simulate circuits as much as three times faster than standard Berkeley Spice.

Like Valid, Daisy has developed its own version of Spice, which the company calls DSpice. The vendor reports that DSpice exceeds the speed of Berkeley by about a factor of two. If DSpice is too slow for you, you might consider the Daisy's $18,000 ChipSim package, which uses a different set of analysis algorithms than Spice. By taking a slightly different approach to circuit simulation, the program (developed by Shiva Multisystems of Menlo Park, CA) can simulate circuits as much as 20 times faster than Spice can.

No matter how fast a circuit simulator can run, the program is useless if it can't call on an adequate component library. Daisy's $18,000 Analog Libraries, for example, gives you 150 analog components and about 150 additional equivalent parts. Components in the library include discrete devices such as bipolar transistors, op amps, voltage regulators, timers, and phase-locked loops. Using this device library, you can analyze circuits containing components like the op amp in **Fig 2.**

Large libraries can save time

You don't need to restrict your designs, however, to just the components in the Analog Libraries. Daisy's Analog Device Library Builder (ADLiB) provides a macromodeling software package that lets you compile data-sheet characteristics into analog-IC models. Using this program, you can characterize components that you can't find in the Analog Libraries. You can also alter the characteristics of components in the library to reflect worst-case and what-if conditions. To obtain device characteristics, you can interface the $25,000 program to Hewlett-Packard parameter analyzers and capacitance meters.

You can obtain the largest analog component library from Analog Design Tools, the first company to develop a workstation just for analog design **(Ref 1).** The company's General Device Library Module contains more than 700 device models. What's more, you can run the company's enhanced version of Spice, Spice Plus, on these device models. In addition to offering the usual circuit-simulation features in Spice,

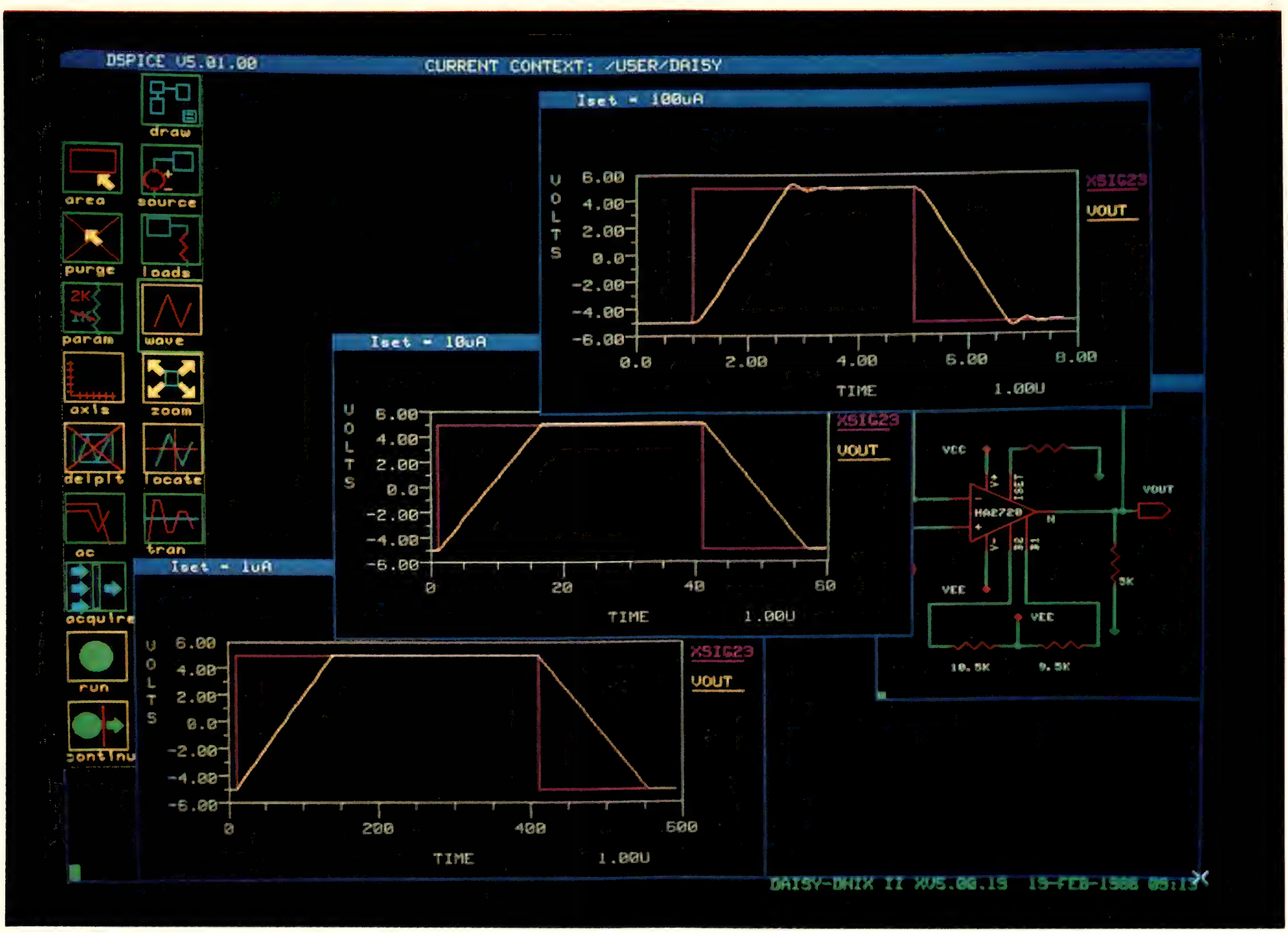

__Fig 2—In this simulation of an op-amp circuit,__ Daisy's DSpice models the shape of the output voltage waveform for three values of the external set resistor.

Spice Plus lets you simulate temperature effects, short-channel MOSFETs, and distributed RC effects in transmission lines.

To enter your test conditions into the Analog Workbench, you simply set the controls on simulated test equipment. If you need to carry out nonlinear time-domain tests, you can combine a multichannel function generator and a multichannel oscilloscope. For work in the frequency domain, you can select a simulated frequency sweeper and a multichannel network analyzer. The package also provides you with a dc multimeter and a spectrum analyzer.

Magnetics attract interest

In addition to ordinary analog components, the creator of the Analog Workbench has just introduced a library of magnetic components. Because this package lets you simulate magnetic effects, you can use the program to design power supplies and instruments that contain power supplies. The magnetic-simulation software includes magnetic-core and air-gap effects.

Unlike other analog-design packages, you can run the $25,000 to $55,000 Analog Workbench on a variety of workstations. The program runs as a stand-alone package on 32-bit workstations from Sun, Apollo, and Hewlett-Packard.

Because two CAE vendors have integrated the Analog Workbench database into their general-purpose CAE systems, you can now integrate your analog designs into complete system designs that comprise analog and digital sections. Hewlett-Packard is just now adding the Analog Workbench to its DesignCenter CAE software. What's more, Mentor is just now announcing its integration of the package in its Apollo-based CAE software. Using the new HP and Mentor integrated packages, or similar ones from Daisy and Valid, you can combine digital and analog designs into a complete system design and then generate your pc-

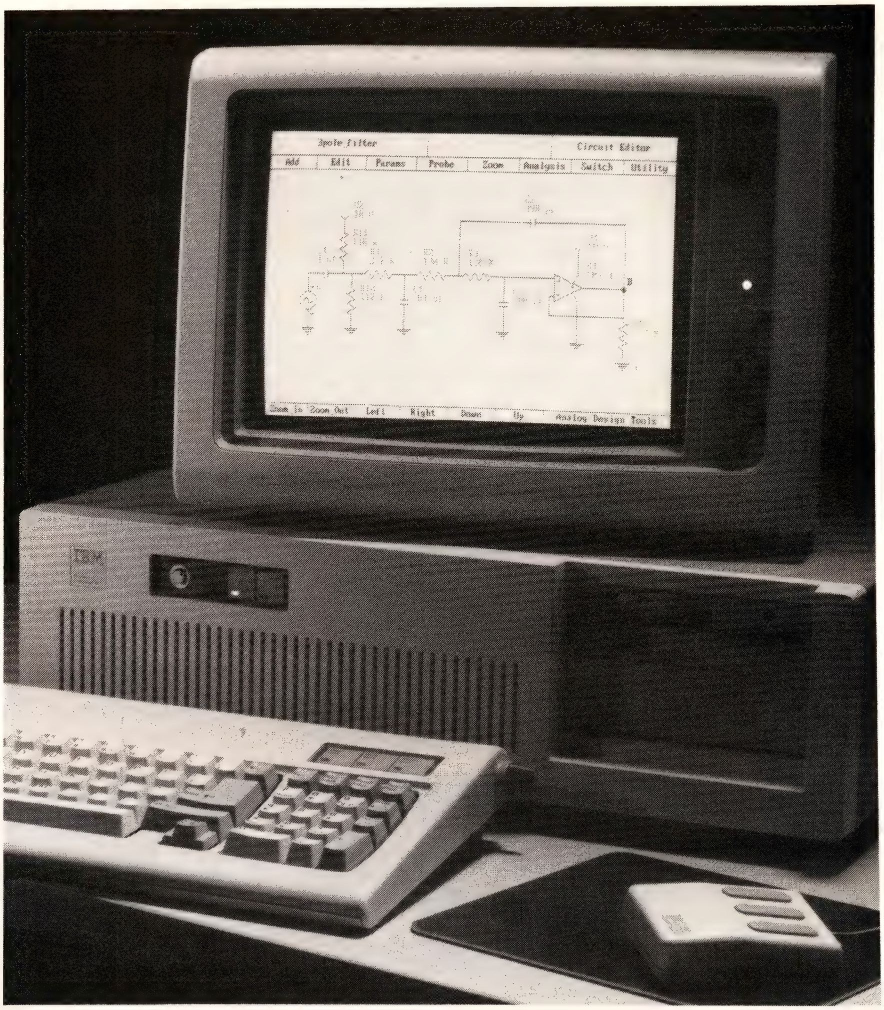

Fig 3—When you plug a 32032-based coprocessor board into an IBM PC, *you can run Analog Design Tools' analog-design software on a personal computer.*

board layout on one workstation.

If you are looking for a less expensive analog-design package, you may want to select the PC Workbench, Analog Design Tools' recent port of its software to the IBM PC. The package **(Fig 3)** runs the same programs as the Analog Workbench, but simulations take about two to three times longer, and the PC Workbench doesn't include a multiple-window capability. However, for $12,500, you do get the complete analog-design software package, a 32-bit coprocessor board, and a mouse.

The PC Workbench is hardly the least expensive product for analog design. If you need to run only standard Spice simulations and can use an IBM PC or compatible personal computer, a variety of programs in the $100 to $1000 price range can satisfy your requirements **(Ref 2)**. Among the vendors of low-cost Spice packages are Acotech, E/Z CAD, FB Circuit Products, MicroSim, Spectrum Software, and Tatum Labs. In fact, you can find programs as modestly priced as BV Engineering's $73 ac network-analysis package, ACNAP.

Time-shared analog design

At the opposite extreme in price and performance from the PC-based Spice packages is Control Data's Syscap 2.5. This circuit-analysis program comprises three modules that let you analyze circuits in transient, dc, and ac modes. The first module, Dicap, performs dc or steady state, worst-case, Monte Carlo, and stress analyses. The sec-

So, Is There a Real ASIC Second Source Setup in the Picture?

(Hint: Raytheon's RL7000 and LSI Logic's LL7000 are like . . .)

There's been a lot of wishful thinking about an active, genuine, semi-custom logic array second source. For very good reasons, but without a very good solution. Now, the right people, technology, and systems have been brought together. Raytheon and LSI Logic. It's happening.

☐ **Complete and identical:** Long term maintenance and bilateral updates of well-known LDS™ front and back end software. The same methodology. The same libraries, logic design, physical design, testing. Identical.

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ond module, Alcap, models analog circuits in the ac linear-frequency domain. You can use the third module, Tracap, to perform dynamic or transient analyses, including time response to normal conditions, radiation, and transient stresses.

Syscap 2.5 is ideal (and often required) for military designs because the extensive library contains most MIL-spec components. The library also aids the program in calculating the sensitivity of a circuit to variations in its components. Furthermore, because Syscap 2.5 can model

Program enhancements simplify microwave/RF design

Two companies, EEsof and Communications Consulting Corp (CCC), have developed CAE programs that can help you design microwave and RF circuits. To aid you in microwave and RF design, these competitors have improved their software extensively in the past year.

One new product is Cadec+, an enhancement of CCC's Cadec package. Cadec+ analyzes frequency-dependent models of microstrip lines and lumped elements at frequencies as high as 40 GHz. By analyzing nodal noise, the program can evaluate both correlated and uncorrelated noise sources. To assess the effects of spec variations, the microwave CAE package features a function that simulates analog component tuning. Cadec+, which costs $10,000, runs on HP 9000 Series computers. Cadec-L, a $5000 option to Cadec+, accepts data from Cadec+ and prints artwork directly on Mylar film.

In addition to enhancing its own software, CCC has acquired Compact Software, the creators of the Super-Compact, and integrated Super-Compact into its line of CAE software. Super-Compact can design circuits that contain highpass, lowpass, and bandpass filters; broadband transistor amplifiers; equalizers; matching networks; oscillators; reflection-type amplifiers; pin-diode attenuators; switching circuits; low-noise amplifiers; branch-line couplers; and multiple-terminal devices. The program runs on IBM PCs and compatibles; Apollo workstations; DEC VAX and HP 9000 minicomputers; and Control Data and IBM mainframes. The cost of Super-Compact varies with the CPU that you use; prices range from $10,500 to $85,000.

Microstrip models extend microwave CAE

Like CCC, EEsof has introduced enhancements to its microwave- and RF-design software. In addition to the features incorporated in earlier versions of the Touchstone program, Touchstone 1.4 provides models of asymmetric coupled-microstrip transmission lines; 6- and 8-finger interdigital couplers; vias; linear tapers; and microstrip slits, gaps, bends, and radial lines. Moreover, the program can incorporate equations for element values in a circuit and can optimize gradients. Touchstone 1.4 is able to handle dielectric and magnetic loss, as well as permeability, in waveguide and transmission-line physical models.

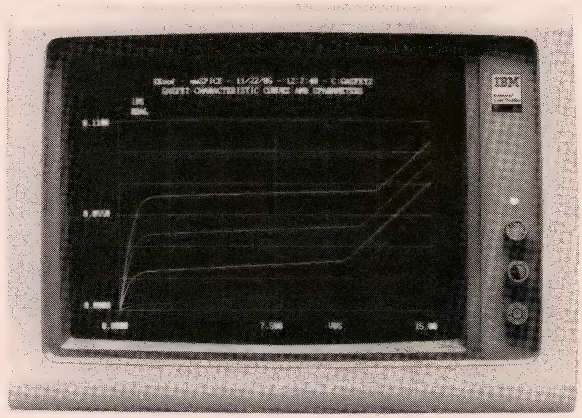

***Fig A—Microwave Spice specializes** in microwave-frequency circuit simulations. The package, from EEsof, produced this plot of a GaAs field-effect transistor's drain current vs the transistor's source-drain voltage drop.*

Touchstone 1.4 runs on IBM PCs and compatible personal computers. The program costs $8400; a $3000 option lets you add custom microwave models to your device library. Touchstone 200, a version of Touchstone that runs on Hewlett-Packard 9000 (Series 200 and 300) computers, costs $8700.

Touchstone 1.4, Cadec+, and Super-Compact analyze microwave circuits at the component level, so you can regard these packages as microwave analogs of programs like Analog Workbench. Until recently, an analog to Spice in the microwave domain didn't exist. Now, by adding microwave models to Spice and adapting Spice to microwave applications, EEsof has created a version of the standard circuit simulator that's specialized for microwave circuits.

Microwave Spice can analyze the S-parameters (transistor characteristics) of elements like the GaAs transistor in **Fig A**. If you specify the physical and electrical characteristics of your circuit, the circuit simulator can model your circuit's performance as a function of your operating conditions. EEsof charges $8400 for the package, which runs on IBM PCs and compatibles that include 640k bytes of RAM.

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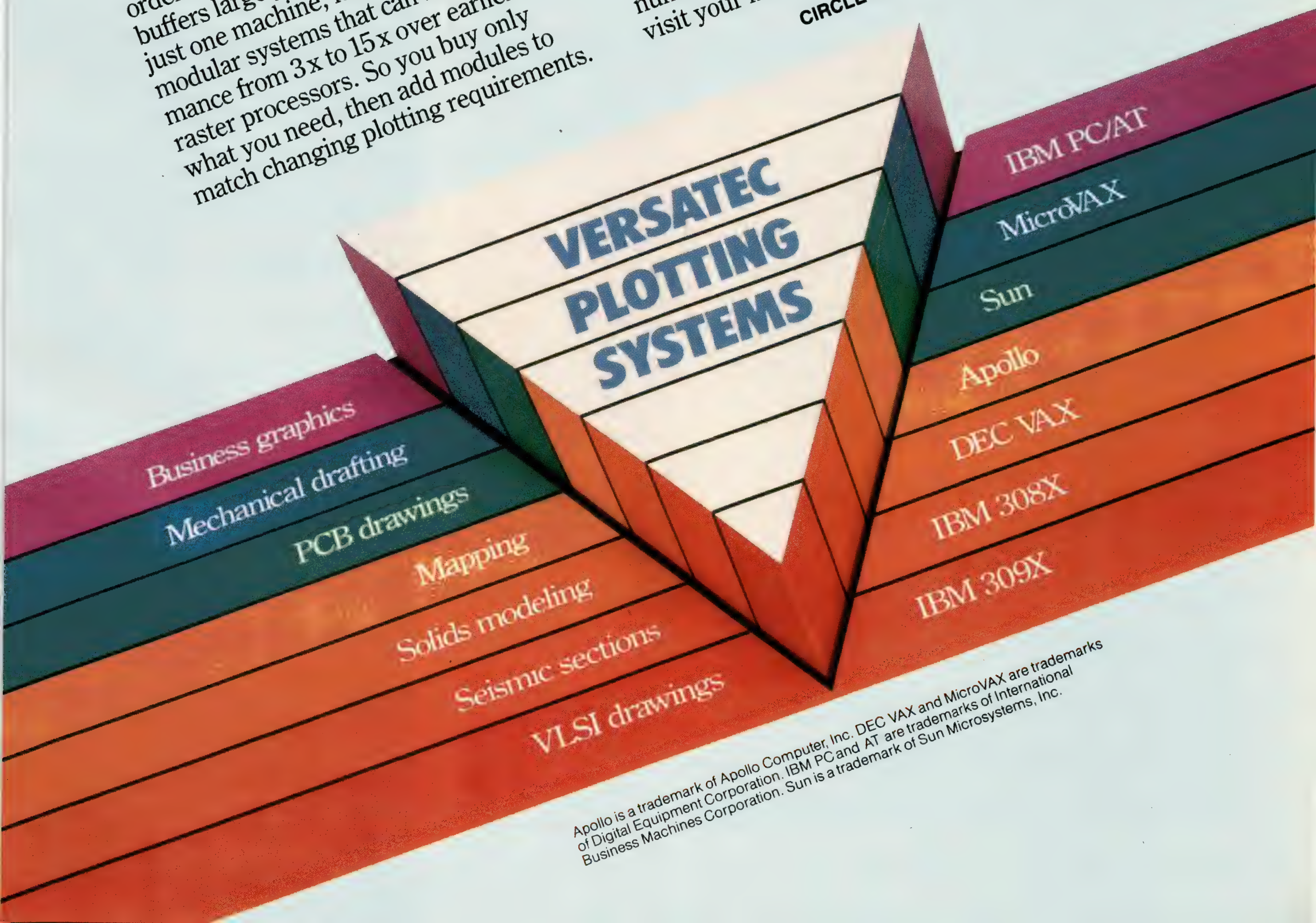

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seven possible turn-on voltage configurations, you can use the program to simulate the effect of turning on a power supply.

The $165,000 Syscap 2.5 circuit-analysis program runs on the company's Cyber supercomputers, as well as on DEC VAX and IBM computers. You don't have to purchase Syscap 2.5; you can access the program on a time-shared basis through Control Data's Cybernet service.

Many engineers, especially those who work on military contracts, design circuits that must operate at gigahertz frequencies. Improvements in analog CAE software haven't been restricted to low frequencies; the **box,** "Program enhancements simplify microwave/RF design," describes recent enhancements to these packages.

Analog CAE software can help you simulate your designs, but your project isn't over once you have verified your circuit. You still must implement your design—and most pc-board layout systems are developed for digital designs, not analog ones. Several pc-board CAD companies, such as Telesis, instruct their layout software to handle the nonuniform characteristics that occur in analog layouts. However, the layout system that focuses most closely on analog designs is Zuken's Analog Designer.

The Analog Designer maintains its routes in a true curve database: Routes aren't combinations of line segments; they are arcs calculated from end points and from a radius of curvature that you assign. Thus, this system can generate exactly the curves that your analog layout requires.

A radial grid lets you place and

For more information . . .

For more information on the analog-circuit design systems described in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

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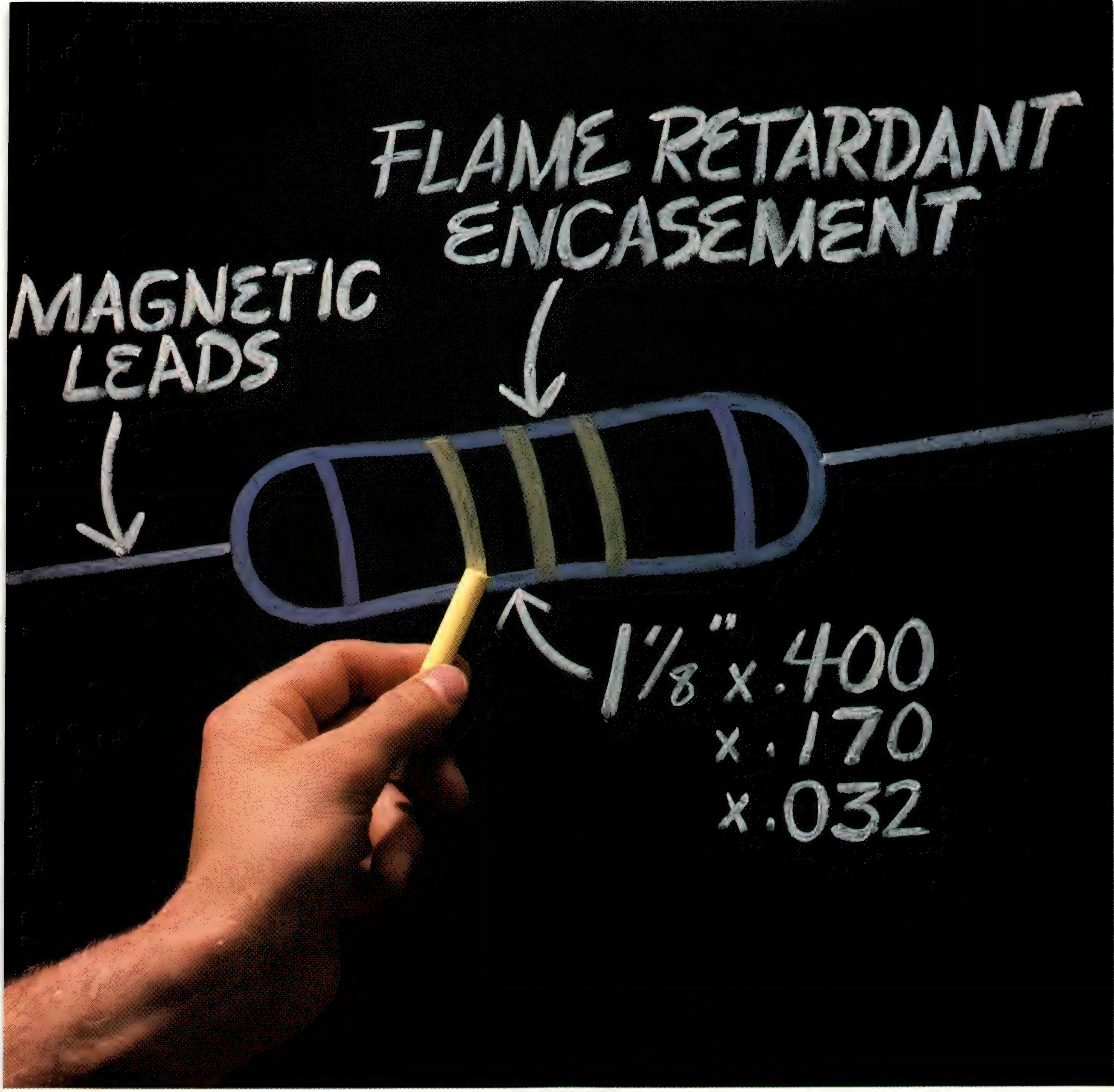

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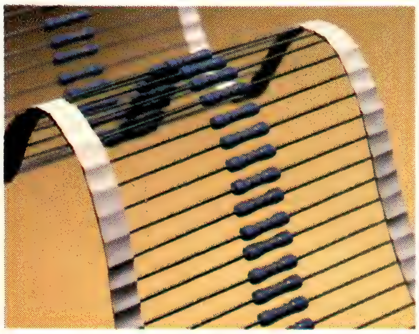

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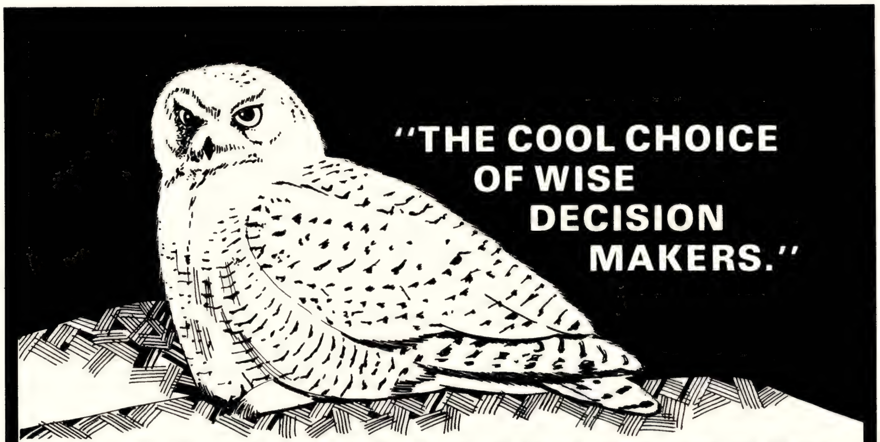

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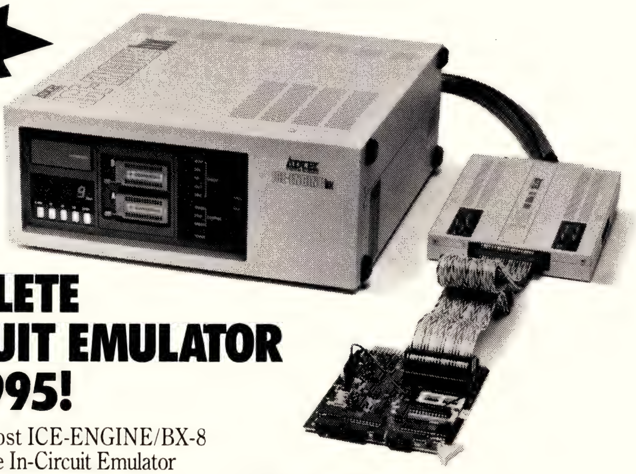

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Zuken's Analog Designer is part of its System 2000 CAD line. The package runs on Hewlett-Packard 1000 computers. Prices for the system start at $90,000.

Other pc-board layout systems will soon address the needs of analog designers, as will programs that combine digital and analog simulation. Last year, EDN concluded that good analog design still required breadboards (**Ref 1**), but the advances of the past year have largely eliminated this requirement.

EDN

References

1. Everett, Chris, "CAE tools for analog design are emerging, but breadboarding remains essential," *EDN*, May 16, 1985, pg 61.
2. Kiefer, Richard, "PC-based programs aid analog-circuit design and analysis," *EDN*, April 17, 1986, pg 175.
3. Colett, Ronald, "Workstations automate analog design," *Digital Design*, February 1986, pg 40.

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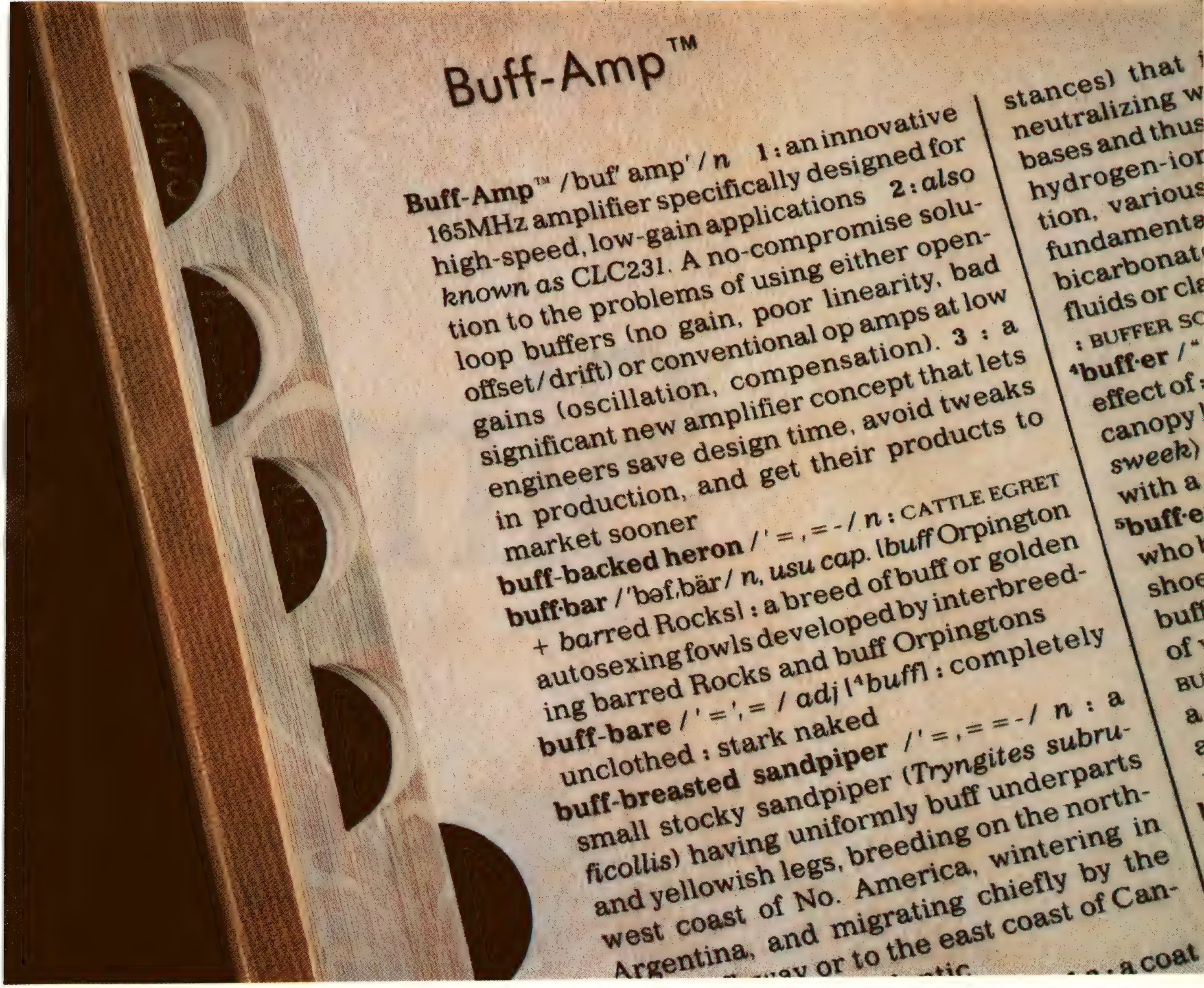

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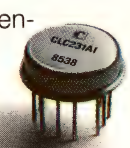

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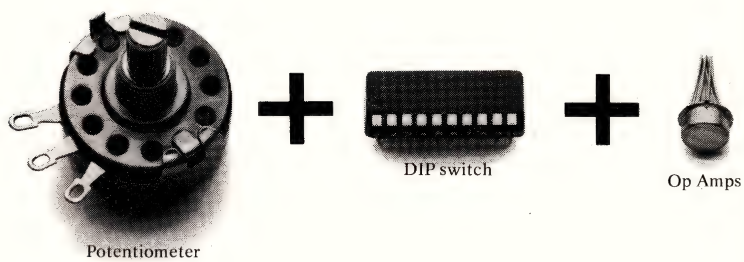

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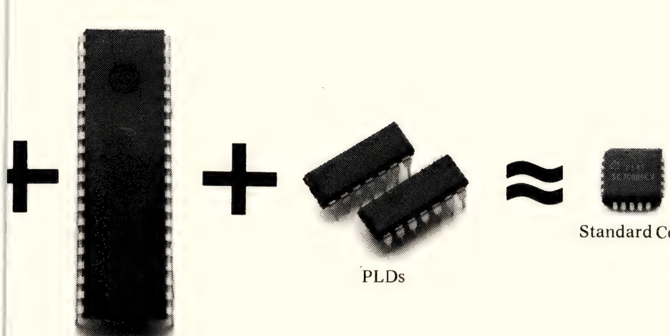

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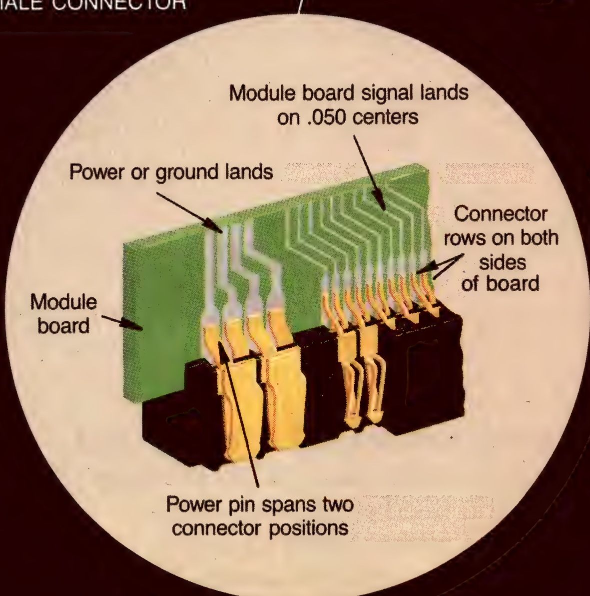

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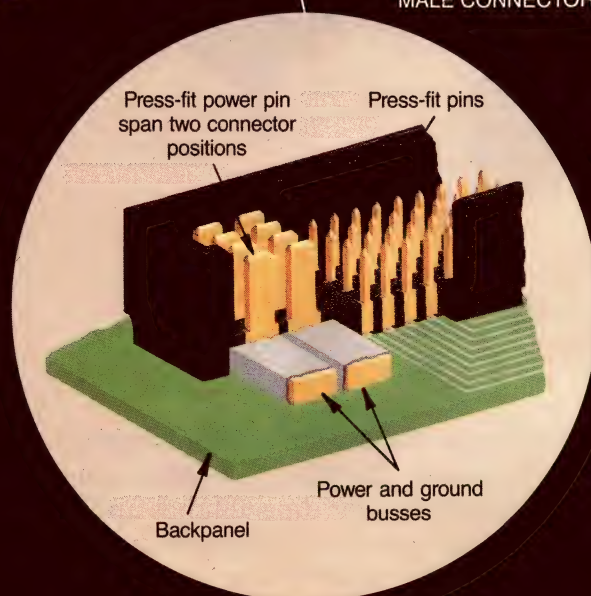

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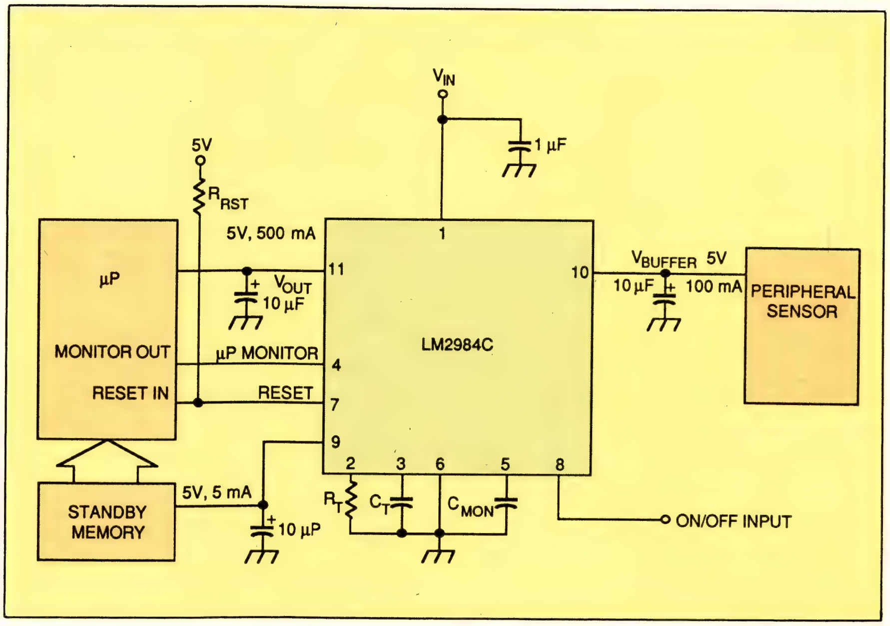
Low cost, low noise, and design simplicity keep linear voltage regulators competitive

Chris Everett, *Regional Editor*

Despite hints at its demise, the venerable monolithic, linear voltage-regulator IC is far from obsolete. Until the switching regulator is as quiet, as easy to design into a system, and as cost effective as the linear regulator, the latter will continue to grow in use—in all likelihood for several years to come. An added attraction is the inclusion of supervisory and protection circuitry on some new linear voltage-regulator ICs. What's more, some parts are showing improved efficiency ratings by virtue of their low dropout voltages.

Switching regulators remain more efficient, however, and use of these devices should grow as well. Of course, manufacturers disagree about the point at which you should leave behind the linear parts and consider the switching regulators, and about the prospects of solving the problems associated with each type of device. Bob Benzer, the new product planning manager for the Bipolar Analog Linear Division at Motorola, says, "The rate of growth of switching regulators is going to be greater than for linear regulators. They're going to start cutting into the linear regulator market because there are new low-cost control ICs, and the magnetics are getting less expensive." Benzer concedes that switching devices pose noise problems, among others, but he believes that attempts to design around or eliminate the flaws are making progress.

Andy Adamian, product and test engineer manager at Fairchild, is not so sanguine about the future of switching-regulator design improvements. You need a lot of magnetics knowledge to design them into a product, he says. For the basic switching regulator, you will find yourself adding capacitors, resistors, an inductor, and probably a power transistor. Even then, you may find that you have introduced an RFI noise source into your system. That noise can, for example, create havoc in your analog measurement circuits or filter ICs. By contrast, one notable advantage of linear regulators is the ease with which you can design them into a system. You add just two capacitors to the basic 3-terminal regulator.



***The three regulated voltage outputs** of National Semiconductor's LM2984C can power a µP-based system with standby memory. The device also has a watchdog circuit that monitors the µP's input current. If no current is found, the LM2984C will send a reset flag to the µP.*

CMOS favors linear parts

Also, the trend towards more use of CMOS circuitry is resulting in systems that require less power. These lower power requirements are relieving linear-regulator manufacturers of the pressure to introduce efficient regulators with current ratings higher than today's approximate 10A limit. At the same time, the changing system power requirements are putting pressure on switching-regulator manufacturers to introduce parts that are cost-effective at power levels below 50W.

CMOS circuitry will also accelerate the push towards distributed power systems and the need for more on-card voltage regulation. CMOS logic requires less absolute power, and the substitution of onboard supplies for one massive supply solves a number of problems. Large, multioutput supplies, besides being difficult to configure into a system by virtue of their size alone, have a higher potential for noise and generate more heat that must be dissipated somehow.

Questions remain about what the practical upper current limits of lin-

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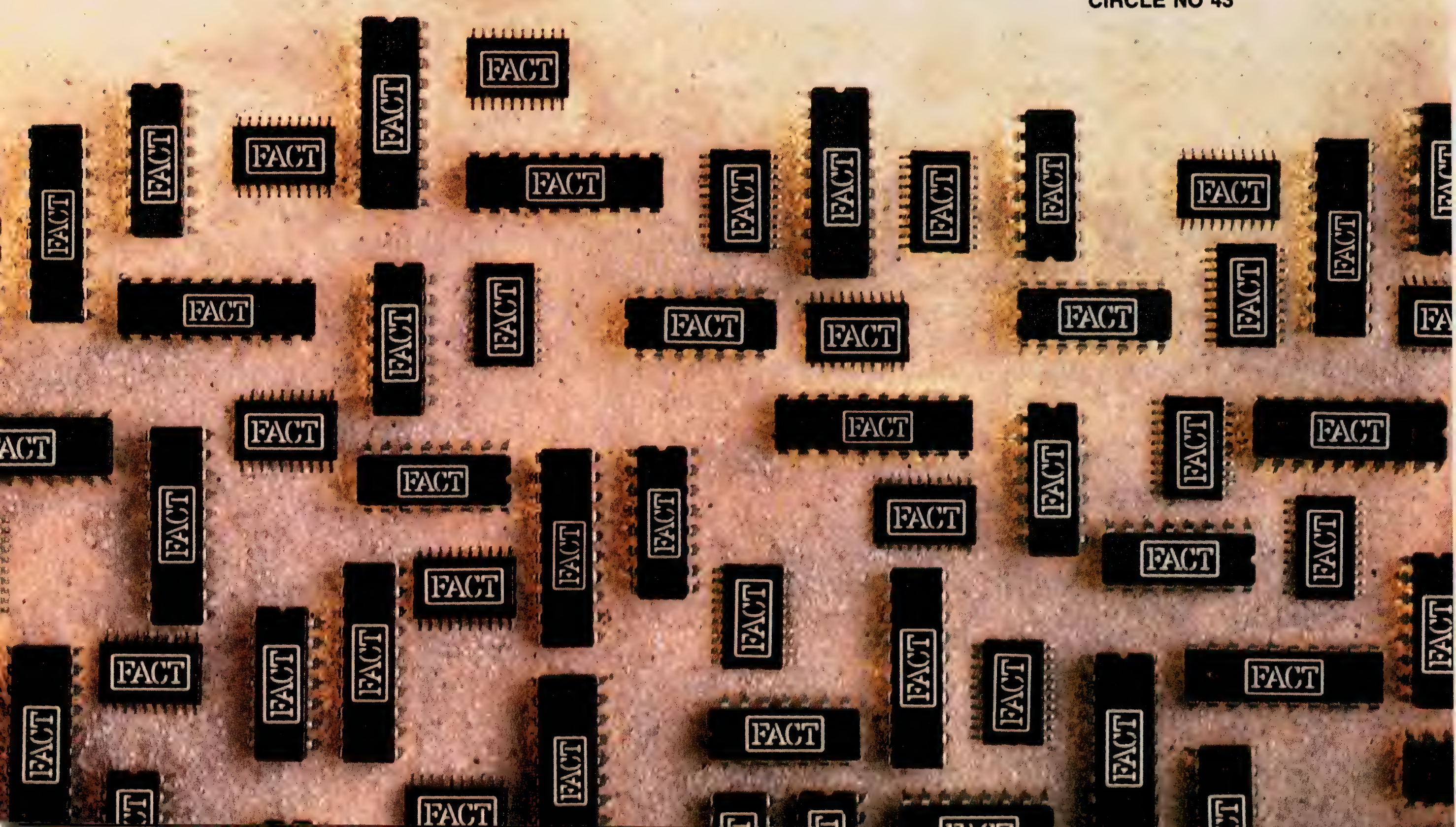


ear regulators are today, whether those limits can be extended, and to what extent new switching regulators will vie with linear devices for applications in the region of these limits. Andy Adamian believes that, beyond 3 to 5A, or 50 to 100W, series regulation has disadvantages because of efficiency and heat-sinking problems.

The emergence of CMOS technology, though it favors linear parts, hasn't drawn a line that clearly defines the appropriate applications areas of the two types of regulators. The use of switching regulators in applications requiring 50W or less makes sense, says Adamian, when efficiency is critical and money is no object. But if the input/output voltage differential is low, Adamian believes, series regulators offer definite advantages. For one thing, dissipation is obviously kept to a minimum.

In a 10A regulator, for example, if the user can keep the input/output differential under worst-case conditions at 5V while drawing 10A, 50W proves not too difficult to dissipate, whether the part's in a TO-3 or a TO-220 package. When you take all the system variables in the worst-case conditions, and when your input/output voltage differential must be in excess of 10V, says Adamian, then the dissipation becomes a major issue. A practical output limit, then, would appear to be in the region of 10A.

3-pin devices still popular

Although the still popular μA723 multipin regulator—offered by Fairchild, Lambda (as the LAS723B), and others—was the first commercially successful monolithic linear regulator, it was the LM309, a 5V device that set the stage for the concept of distributed power management. Its 1A output could support a number of 5V circuits on one pc board. It's easy to design into a system, too; you only need to add one or two bypass capacitors. The LM309 features both output current limiting and thermal-shutdown protection.

The 3-terminal fixed and adjustable linear voltage regulators that followed the LM309 came in an assorted selection of voltage and output current ranges. New devices were introduced with higher current ratings or with improved specifications—most notably tighter output-voltage accuracies, higher ripple rejection, better line and load regulation, and lower quiescent-current needs.

Updates are still being introduced. For example, Silicon General is releasing a redesigned 7800 Series of positive fixed-voltage regulators. Silicon General replaced the zener-diode reference in the older regulators with a bandgap voltage-reference scheme. The redesigned reference gives the regulator tighter long-term drift and better noise specs because of the absence of shot noise associated with the avalanche effect of the zener reference. The company is redesigning the product family because military customers are requesting regulators with tighter specs.

More protection circuits added

Although 3-terminal voltage regulators have current-limiting protection, which can be used in a number of ways to protect the overall system, other threats to the overall system require additional protection circuitry or fault indication. For example, voltage spikes generated by lightning can burn up your regulator and the rest of your system, or power brownouts can cause your supply voltages to drop out of regulation.

Before watchdog-circuit ICs became available, you had to design supervisory circuits with discrete components. These discrete parts consumed more space on the pc board than the voltage-supervisory ICs that eventually appeared (see **box**, "Supervisory ICs complement regulators").

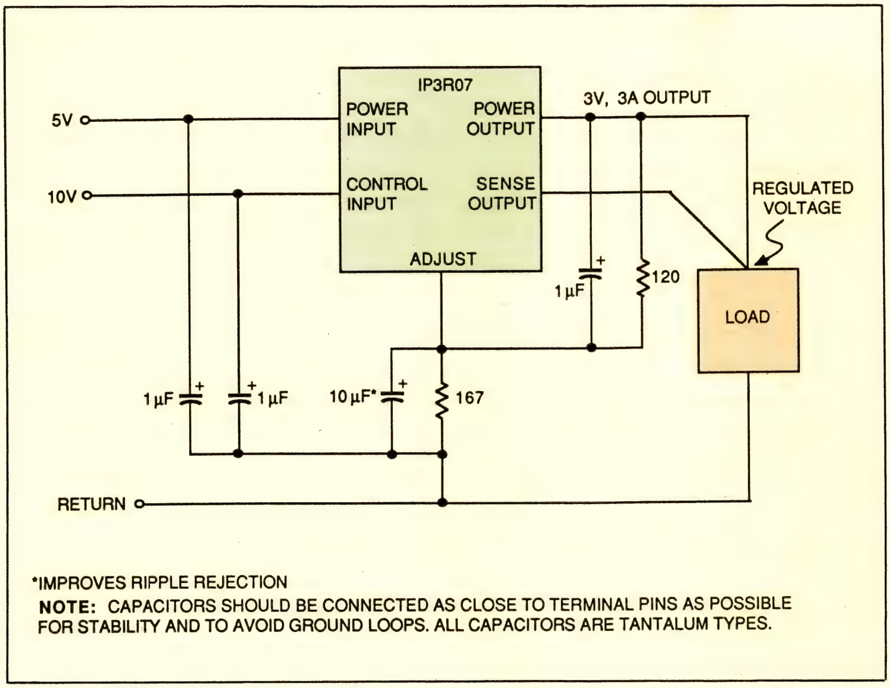
Now you can have the superviso-

Supervisory ICs complement regulators

You needn't be restricted to discrete implementations of watchdog functions or to selection of a voltage regulator that integrates watchdog circuitry on chip. Motorola and Texas Instruments, for example, offer supervisory ICs that complement their extensive lines of monolithic linear voltage regulators.

Motorola's 8-pin MC3425 ($1.40) has two independent over/undervoltage sensing circuits: The minimum allowable overvoltage and undervoltage fault-duration times are independently programmable from 1 μsec to 1 msec. After sensing an overvoltage condition, the MC3425 sources 300 mA at a 2A/msec slew rate to trigger a crowbar SCR for system shutdown. If the MC3425 detects an undervoltage condition, its indicator output sets a flag.

Texas Instruments' TL7702A ($1.00) Series supply-voltage supervisors are strictly undervoltage protection circuits, but with an added feature: They're designed to be used as reset controllers in μP-based systems. During power-up or after the supply voltage returns to its nominal voltage level after an undervoltage condition, the TL7702A holds the μP's reset line active for the time delay that you preset. The delay is designed to give the μP's clock and other system components time to become fully operational before the μP initiates its reset operation. For a multiple-voltage power system, you can gang several TL7702As together to supervise each of the power outputs.



By splitting the voltage input into two parts*—a high-current power input and a low-current control input—Integrated Power Systems boosts its linear voltage regulators' power efficiency from 62% to 86%. The IP3R07 can source 3A with a minimum 0.8V differential between its power input and output pins.*

ry and protection circuitry on the same chip with the voltage regulator. To the $1.10 LP2950, a 3-terminal regulator, National Semiconductor added an undervoltage-detection circuit and a logic-controlled electronic shutdown-control circuit. National calls the resulting 8-pin device the LP2951 adjustable micropower voltage regulator. It costs $1.45.

The LP2951 is designed for use in a battery-powered system. You can program its output for any value between 1.24 and 29V via a pair of resistors. The maximum output current is 100 mA. Although the LP2951 has a higher pin count (eight vs the LP2950's three), you are able to eliminate the extra components needed for an RC reset network, or you can eliminate the voltage-supervisory IC that accompanied the LP2950.

In addition to the supervisory and protection circuitry, you can now get more than one regulator on a chip. An example is National's 2-regulator LM2935. This $1.85 device is intended for use in µP-based systems with standby memory. The device's primary 5V output can supply as much as 750 mA. Its standby 5V output (which is also fully regulated) supplies 10 mA. You can switch the primary output on or off, yet the standby output will remain on as long as the input voltage does not drop below about 5.5V. Also, the standby voltage will remain on even if the primary supply goes into thermal shutdown or is subject to positive line transients.

The LM2935 was designed primarily for automotive applications; its inputs are protected from reverse battery installation and battery jump starts. Its circuitry is also protected against backward installation of the regulator.

National also offers a 3-regulator chip, the $4.65 LM2984C, which furnishes a main output, a secondary (buffer) output, and a standby output. The 5V/500-mA main output is protected against overvoltage conditions and thermal overload. The 5V/100-mA buffer output powers peripheral sensor circuitry and is short-circuit protected. If you accidently short its output, it will shut down, but the other two outputs will remain operational. Both the main output and the buffer output are controlled by an on/off switch. The standby output is not. It will remain on as long as sufficient input voltage is available to the LM2984C.

Device monitors system parts

If the input voltage does drop below an acceptable level, then the supervisory circuitry will set a reset flag to warn the system µP of the error condition. The reset flag also appears any time the main output regulator goes into thermal overload or the output is short-circuited.

Not only can the LM2984C monitor itself for fault conditions, it can monitor other parts of a system. In fact, it can monitor the activity of any device that can provide a periodic square-wave signal. Specifically, the LM2984C's µP monitor is looking for a train of pulses with a period on the order of milliseconds. If the µP monitor doesn't sense the pulses, it will time out and send a reset signal to the system µP.

The three regulated outputs, the internal watchdog circuitry, and the µP monitor come in an 11-pin T0-220 package, which needs a 0.8×0.5-in. plot of real estate on your pc board. It stands about 0.8 in. high. For most common configurations, the LM2984C requires nine additional components—all capacitors and resistors.

Low dropout, high efficiencies

All four of these National devices feature low-dropout voltages. The dropout voltage is the voltage difference between a regulator's input and output pins that specifies when the regulator will cease to regulate against further reductions in the input voltage. The generic 7800 and 7900 series of 3-terminal voltage regulators have dropout voltages on the order of 1.8 to 3V, which means that, if you want a 5V output from one of these devices, you must supply at least a 6.8 to 8V input.

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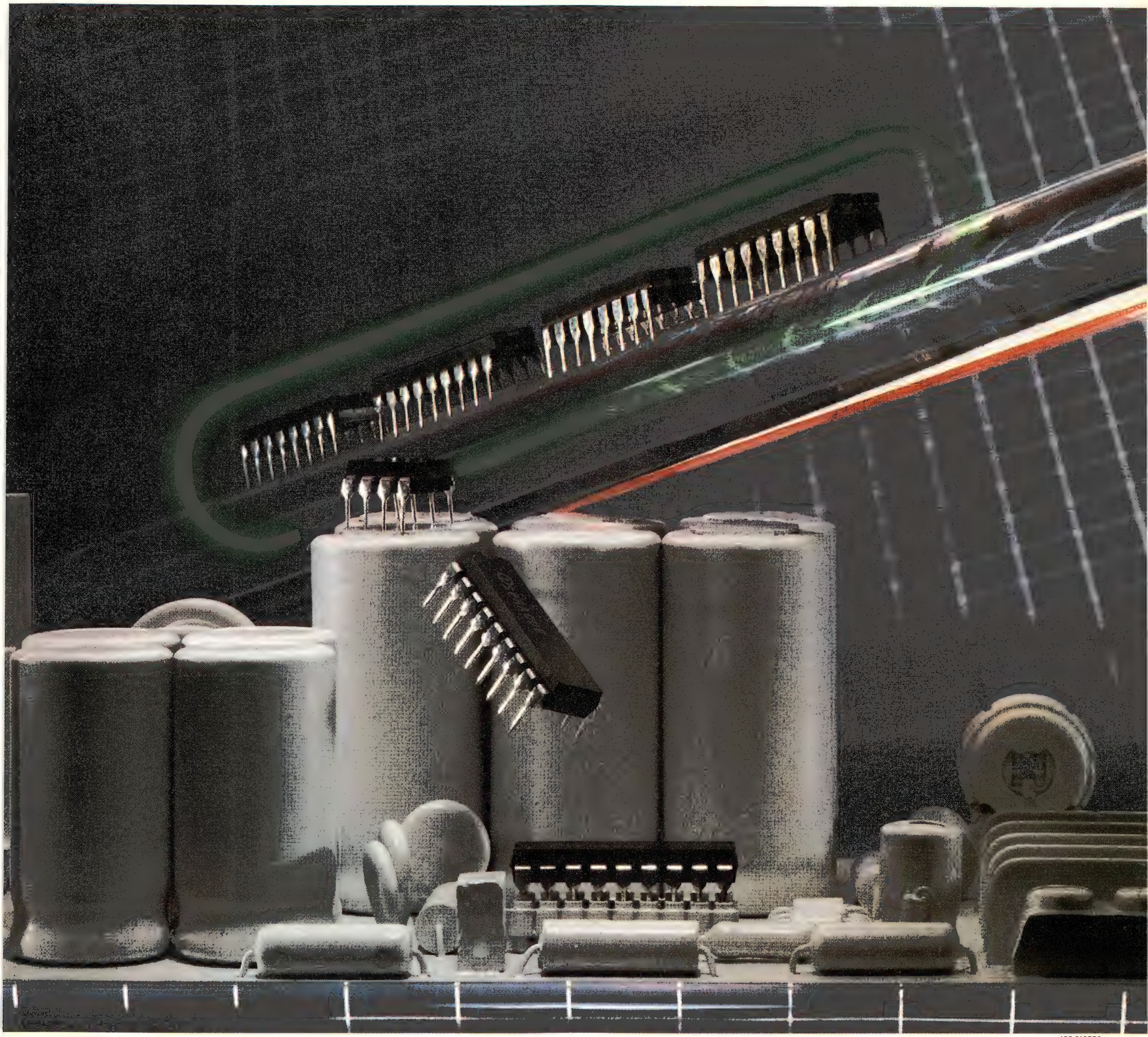

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A voltage regulator's efficiency is directly related to the dropout voltage: the lower the dropout voltage, as a rule, the higher the efficiency. The efficiency of a voltage regulator (actually, it's regarded as an "inefficiency" rating) is the product of the dropout voltage and the current.

The push towards more battery-powered products and the inclusion of more electronics in the automobile made the need for low-dropout regulators more pressing. In response to demands for lower battery voltages and longer product lives, Intersil introduced the $2.15 ICL7663 CMOS programmable micropower voltage regulator, which is now second-sourced by Maxim. The ICL7663 sports a dropout voltage of 0.6 to 1V, the level depending on the saturation resistance of the MOS pass transistor and the load current. The maximum load current rating is 40 mA.

Instead of using CMOS, National has chosen bipolar technology to address the dropout-voltage problem, according to Roy Essex, industrial linear product marketing engineer. National's $0.80 LM2930 3-terminal positive regulator uses a pnp pass device and specs a dropout voltage of less than 0.6V and an output current in excess of 150 mA.

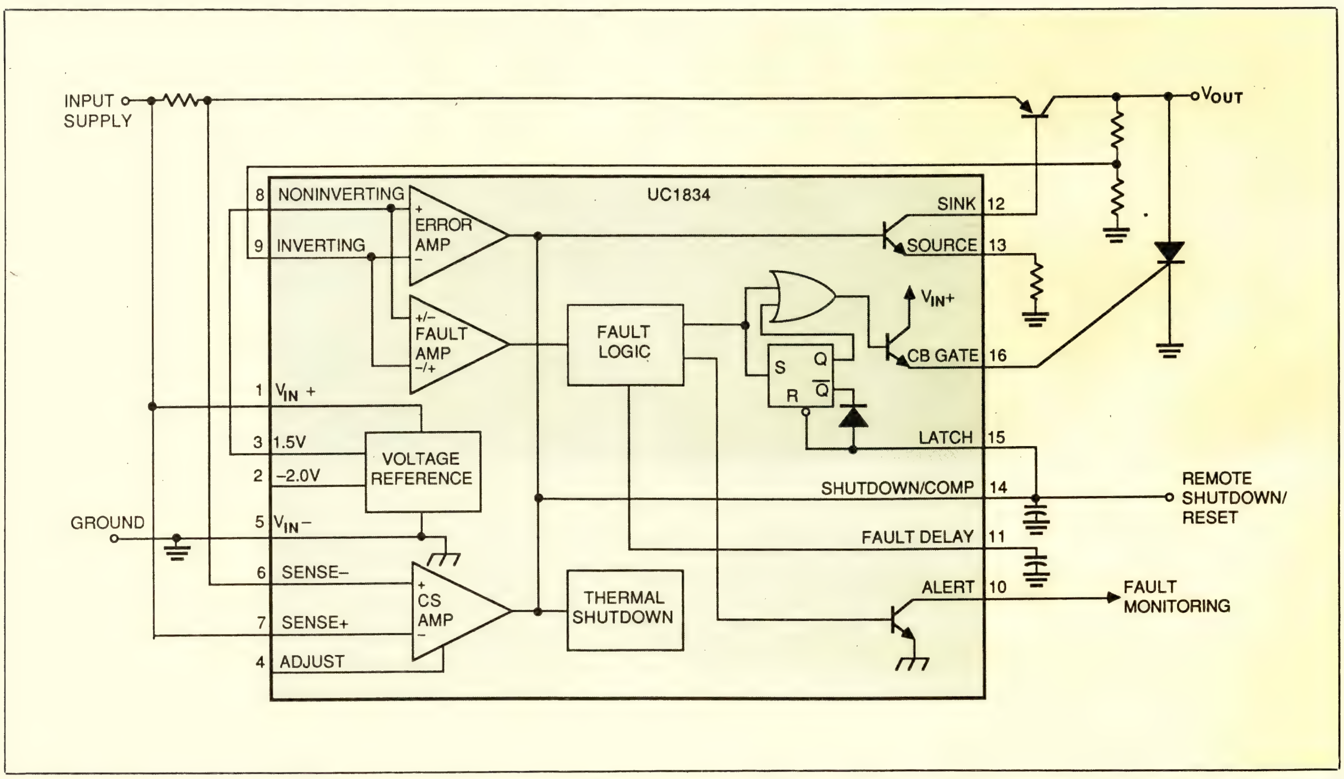
As the automobile industry pushed for more power, National responded with the $1.10 LM2940CT, a 3-terminal positive regulator that can source 1A at a dropout voltage of 0.5V. You can order either a 5, 12, or 15V version. All three versions furnish current-limit, thermal-overload, reversed-battery, and backwards-insertion protection.

You give up some design ease

Integrated Power uses a different approach to produce a low-dropout 3A regulator. Instead of using a pnp pass device, the IP3R07 employs an npn device with a split-voltage-input scheme. The npn pass transistor was chosen because it exhibits much better stability than a pnp device. In the latter, the collector of the device acts as the output. Its gain is therefore dependent on the load impedance. Normally you would use a large output capacitor to set the dominant loop pole, but this approach can be costly, and it still won't guarantee unconditional stability for reactive loads. The npn pass device operates as an emitter follower; compensation within the IP3R07 itself achieves stability.

The use of two voltage inputs—a high-current input and a low current input—gives the IP3R07 a dropout voltage of 0.8V at 3A. The high-current input is the power input. Because it's only seen by the pass device and not by the regulator's control circuitry, you can set its voltage level at one saturation-voltage value above the desired output voltage. For a 5V output, for example, you would set the high-current input voltage at 5.8V.

The control circuitry doesn't need high current to operate: Milliamperes suffice. The power consumed by the control circuitry is low (3V times a few milliamperes) and contributes very little to the operating



A 5A output with less than a 0.5V drop *across a discrete pass transistor is possible when the pass device is controlled by Unitrode's UC1834 or UC1835 linear regulator.*

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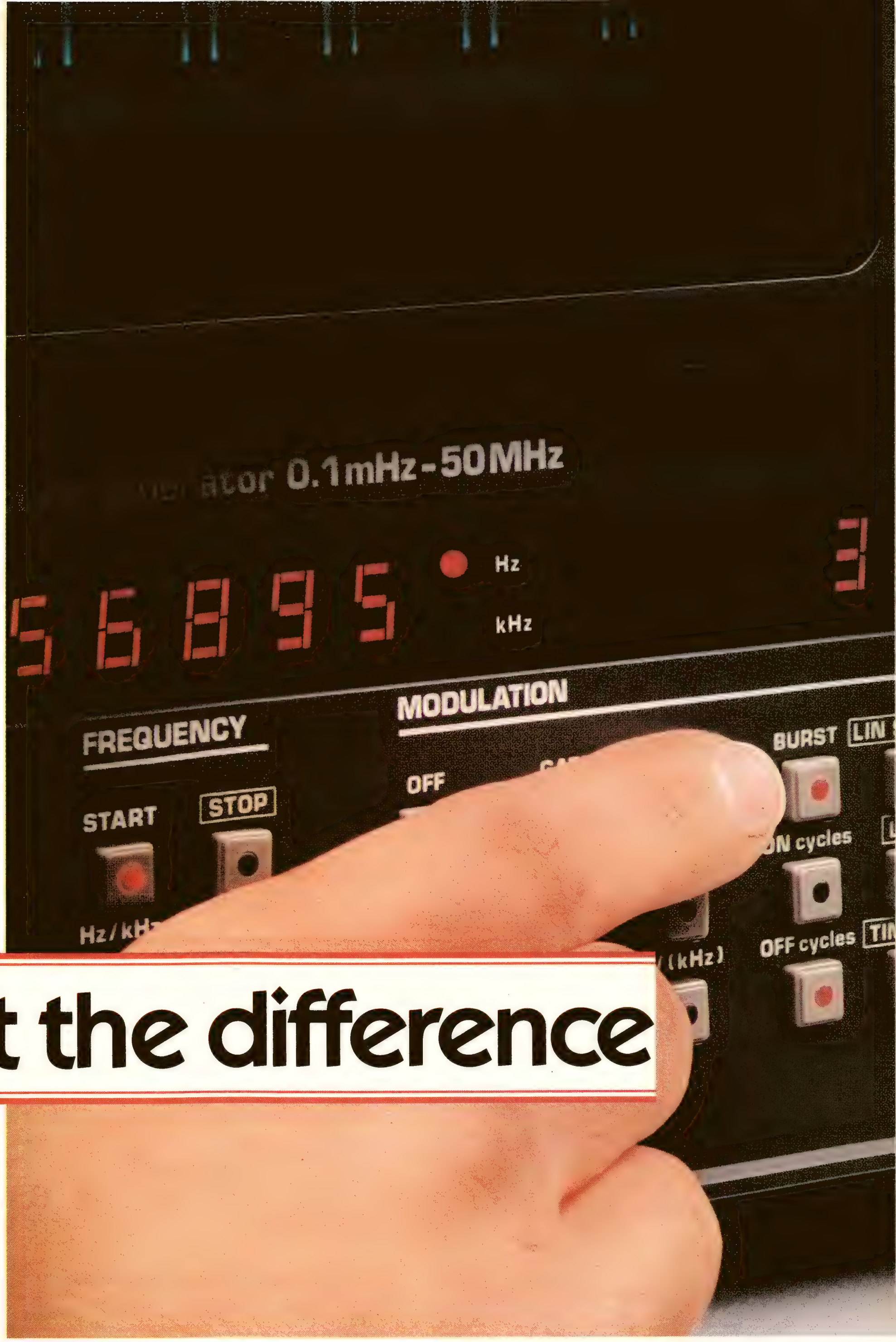

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CIRCLE NO 47

inefficiencies of the regulator. In fact, by using the IP3R07 regulator, you will increase operating efficiency about 38%, from a 62.5% power-efficiency rating for a typical 3V-dropout voltage regulator operating at 3A, to 86.2% for the IP3R07. Note, however, that your design will be constrained by the need to bias the second input voltage 3V above your desired output.

Two devices for dual inputs

In one final low-dropout regulator of note, Unitrode has also opted for an npn pass device as the basic element. But instead of using a dual voltage input, Unitrode combines two devices: the UC1834 regulator, which holds all the regulation and watchdog circuitry, and a discrete power transistor. When configured with a 5A pass device, the UC1834 forms a circuit that exhibits a dropout voltage of less than 0.5V.

The UC1834 has both a positive and a negative voltage reference, so you can use it as either a positive or negative voltage regulator. You can also configure the UC1834's current-sense amplifier with either the positive or negative implementation. The device also provides overvoltage and undervoltage fault-detection circuits. When the UC1834 detects a fault, it raises a fault-alert flag and activates a 100-mA crowbar output that can shut down the pass transistor's output. If you mount the UC1834 near the pass transistor on the same heat sink, you can use the UC1834's thermal-shutdown circuitry to monitor the pass transistor as well. If you don't want to pay the price—$3.15—for all the protection circuitry on the UC1834, you can go with the $1 UC1835. **EDN**

Article Interest Quotient
(Circle One)
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For more information . . .

For more information on the linear voltage-regulator and watchdog ICs described in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

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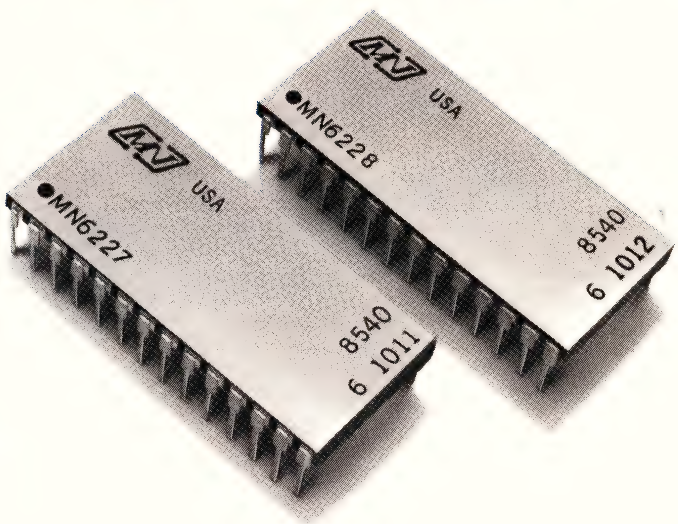

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Note the FFT spectra (right) and the data plot (top right). They clearly demonstrate the ability of these devices to maintain SNR with increasing input frequencies. In our frequency-domain testing, these devices operate in a manner that simulates a

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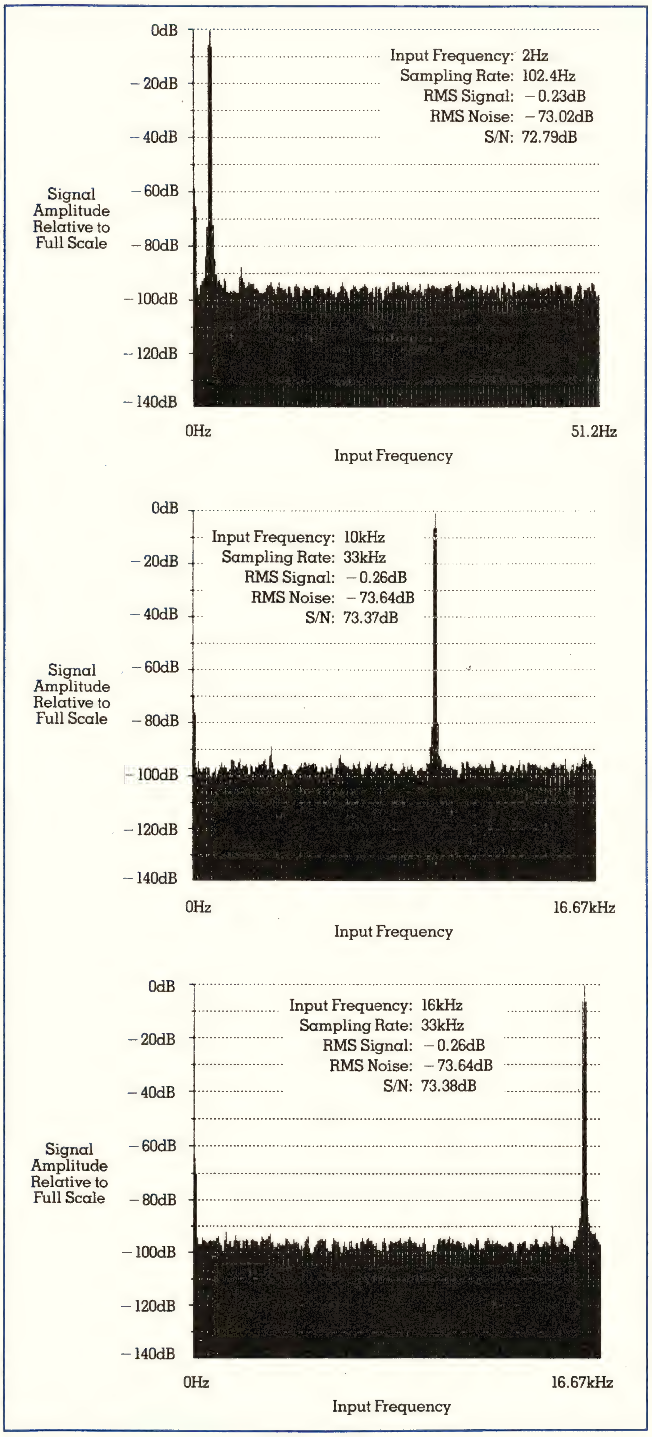

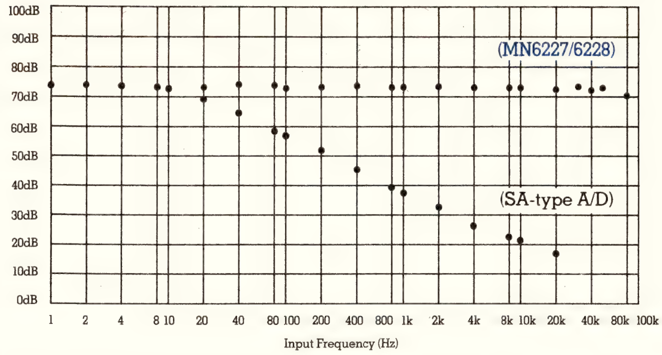

This plot of actual recorded data demonstrates MN6227/6228's ability to maintain near-ideal SNR with increasing input-signal frequency, while A/D's without companion track-holds show rapid (6dB/octave) SNR degradation.

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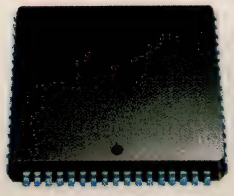
SIEMENS



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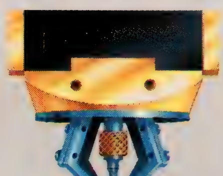
MD  –
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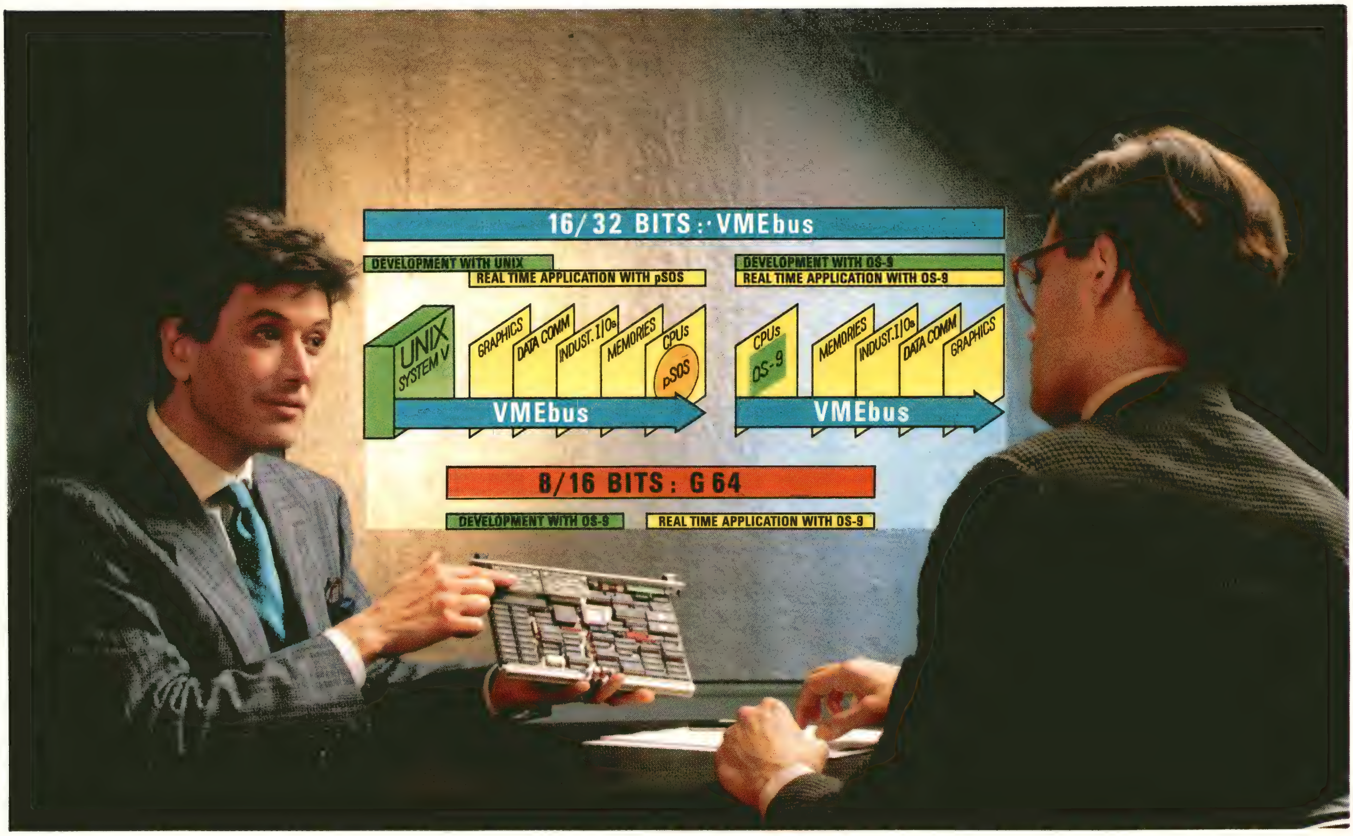

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Machine-vision hardware and software provide speed and computational power

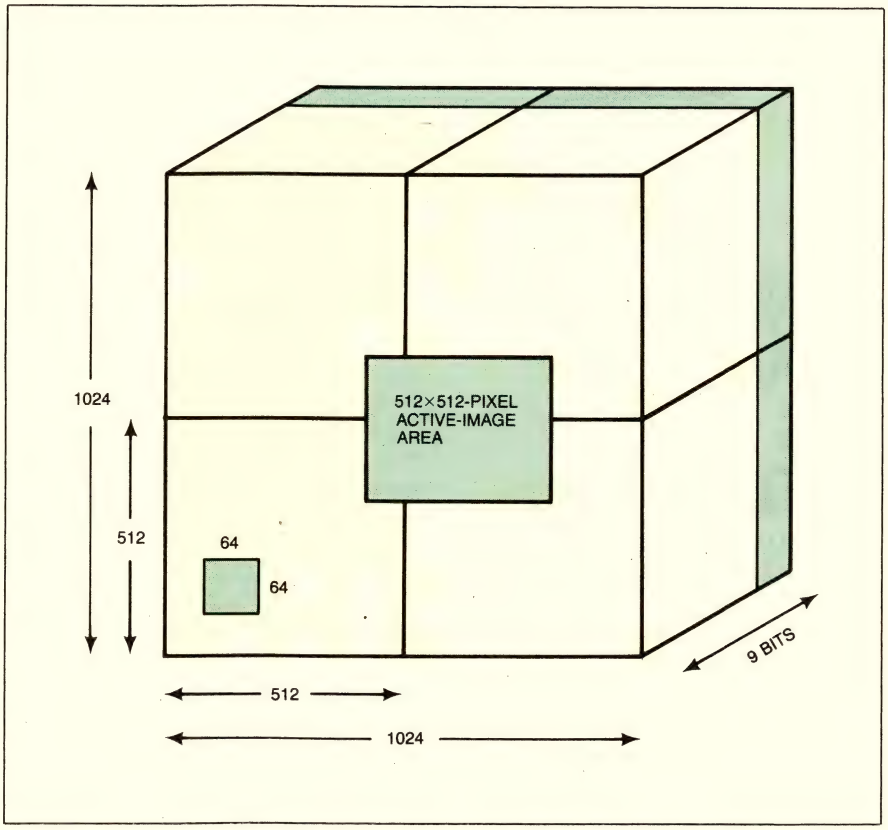
The DS-541M memory-mapped Multibus memory board, an addition to a line of "vision engine" hardware, accommodates machine-vision algorithms that allow on-line access to multiple images and/or repeated access to intermediate results in a chain of calculations. The board holds four 512×512-pixel images and is compatible with the manufacturer's image-processing product line as well as with other vendors' machine-vision hardware.

The memory board **(Fig 1)** contains a memory array of 1024×1024 pixels, each having 9 bits of depth (resolution). Onboard pan and scroll hardware allow any 512×512-pixel window to be active for video input or output at any one time.

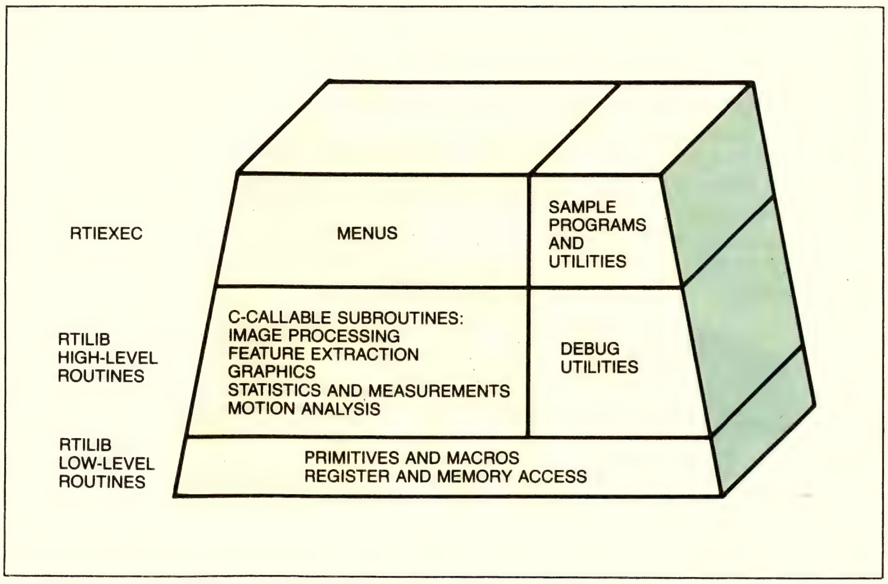
Most high-performance video digitizers used in machine vision and image-processing research provide 8-bit resolution. You can use the ninth bit in the DS-541M memory-storage unit for plane and pixel protection or for graphic overlays. When you use the memory card with the manufacturer's PX-501M Multibus-based pipelined pixel processor, for example, you can use the ninth bit for state information.

The state information is useful in such advanced imaging algorithms as region growing and complex segmentation schemes. For applications requiring more than 8-bit resolution (for example, temporary storage of data resulting from 3×3 convolutions of a video input), you can use two DS-541M units to provide a larger image-memory space, organized as 1024×1024×18 bits.

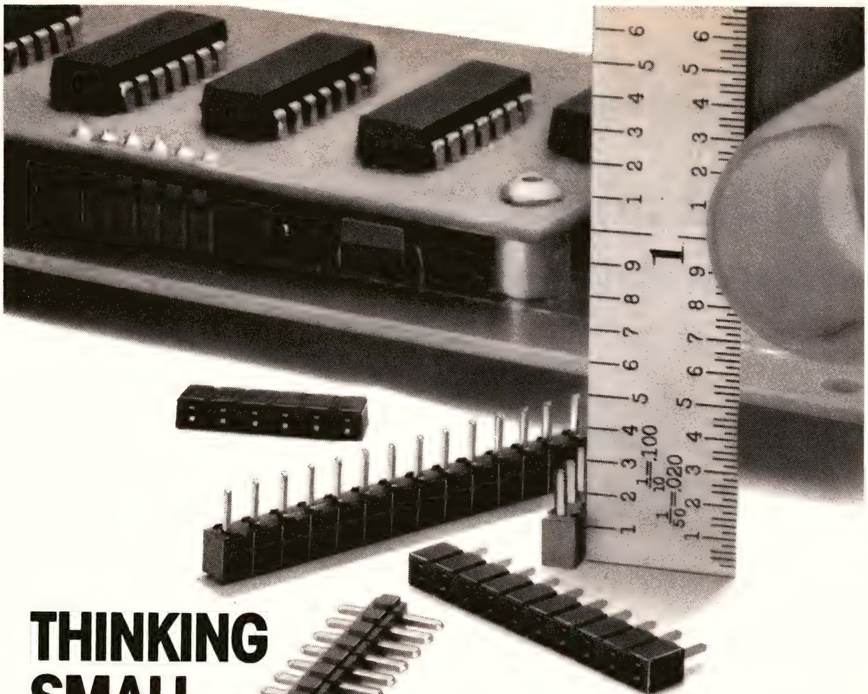
You memory-map the DS-541M into the host Multibus processor's memory space. The pan-and-scroll hardware operates over the entire 1024×1024-pixel space; the window to the Multibus address space can have any of the following dimen-



Able to hold a high-resolution image of 1024×1024 pixels, *the DS-541M memory board allows any 512×512-pixel image to be active at any one time. The 512×512-pixel image size is compatible with many machine-vision systems.*



Using C, you can call more than 300 subroutines *from RTILIB for machine-vision applications. The software handles tasks ranging from image acquisition and enhancement to feature extraction and data reduction.*



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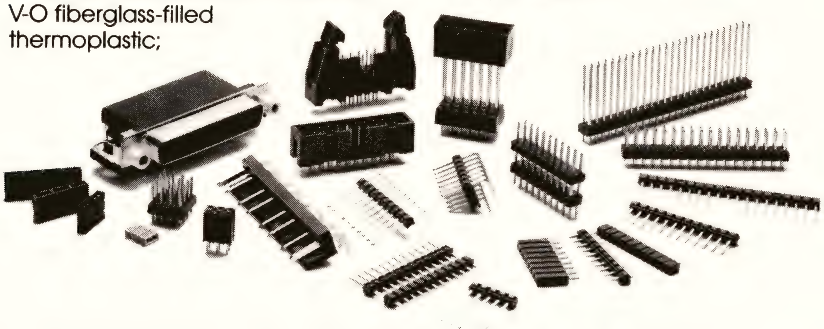

CIRCLE NO 54

3M

sions: 64×64, 128×128, 256×256, or 512×512 pixels. The memory card is also available in a register-accessed version (Model DS-542). Both versions cost $3495.

Released concurrently with the DS-541M, the RTILIB software product uses artificial-intelligence concepts to cover machine-vision needs, from image acquisition and enhancement to feature extraction and data reduction. The program includes more than 300 C-callable subroutines and a menu-driven executive.

RTILIB works with the manufacturer's machine-vision hardware. The software comprises three separate layers; this structure simplifies the task of applying standard routines to custom applications. The top layer, RTIEXEC, is an interactive, menu-driven program that can execute most of RTILIB's subroutines. Through RTIEXEC, you can gain easy access to image-processing operations without having to write any code.

The second layer contains high-level routines that perform the most common image-processing algorithms, including image transforms and utilities, filters and convolutions, region growing, arithmetic and statistical operations, and graphics.

The bottom layer of RTILIB contains low-level routines that provide access to the control and status registers and data tables of the manufacturer's various image-processing hardware modules. These low-level routines allow you to write your own machine-vision and image-processing algorithms. RTILIB comes with source code and is available for four types of host systems: Multibus computers, the IBM PC/XT and PC/AT, the Masscomp MC500, and Sun 2 workstations. All versions, $1500 initial license fee.

—Bill Travis

Recognition Technology Inc, 335 Fiske St, Holliston, MA 01746. Phone (617) 429-7804.

Circle No 731

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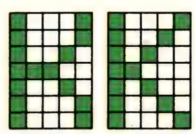
Brilliant display, a choice of colours, wide viewing angle and easy installation – these are the characteristics of NEC's Fluorescent Indicator Panels FIP for efficient and error-free communication between man and machine. To dovetail with different applications, NEC offers compact FIP-Module series ranging from 20 characters x 1 line to 40 characters x 6 lines, plus a graphics version with a 180 x 48 dot matrix. The ROM-based character generator can be selected (and changed) to accommodate different language fonts. Or talk to NEC about customized solutions to enhance your particular application.

Model	Number of Lines	Characters per Line	Character Size (mm)
FM20X1AA-D	1	20	5.05 x 3.55
FM20X1DB-A	1	20	9.00 x 6.30
FM20X2AA-C	2	20	5.05 x 3.55
FM40X1AA-B	1	40	5.05 x 3.55
FM40X1FB-B	1	40*	8.80 x 3.55
FM40X2CB-A	2	40	5.35 x 3.55
FM40X6AA-A	6	40	5.00 x 3.50
FM80X2AA-A	2	80	3.50 x 2.05
* 5 x 12 Dot Format			
FM180GX48BA-A Graphics Module with 180 x 48 dots			



Installation is straightforward. The FIP-Modules operate from a single 5V power supply, come complete with driver and are connected directly to the bus. The sharply defined characters of the fluorescent display are easy to read from virtually any angle. This means increased safety even in tricky lighting conditions or total darkness. Displays are available for clear readability against any background.

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Sweden: Täby 08/73 28 200, Telex 13 839
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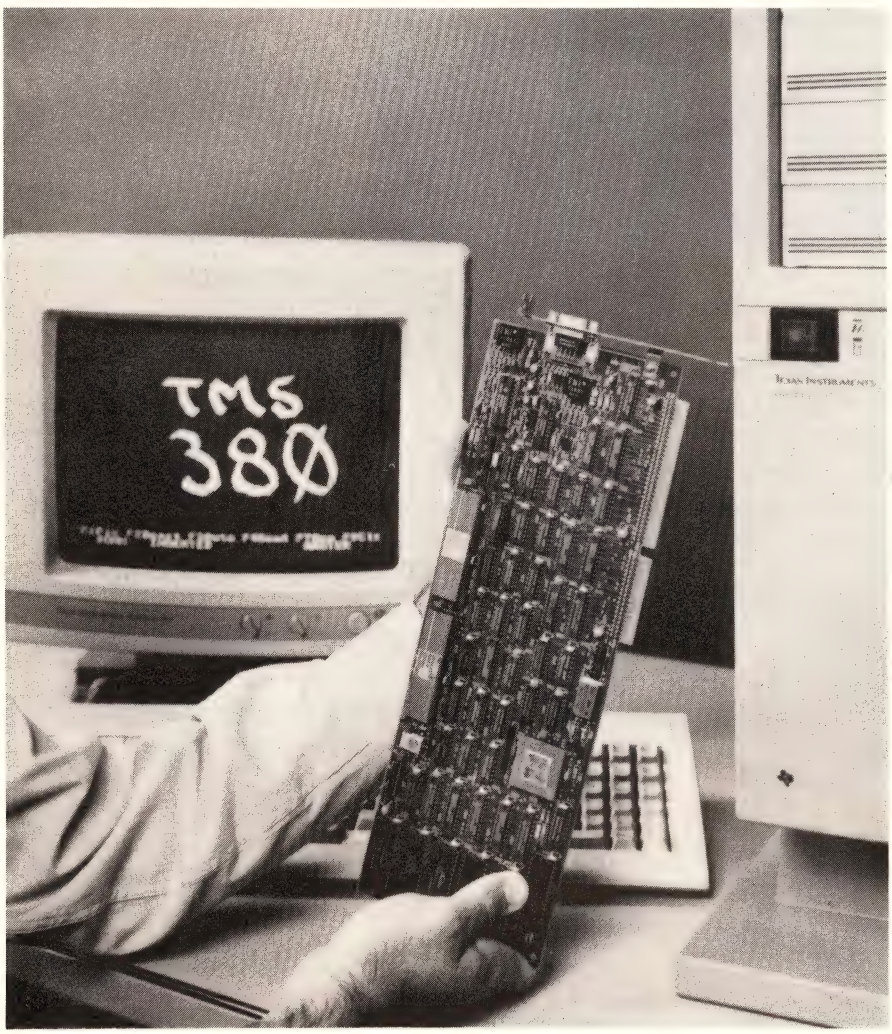
NEC

Token-ring development tools let you analyze LAN protocols and performance

The TMS380 development tools can help you develop systems that are compatible with the IBM token-ring network. The TMS380 tools let you establish an operating token ring in less than half an hour; you can then use them for protocol analysis and performance testing.

Among the development tools offered are adapter cards for the 8-bit PC bus or 16-bit PC/AT bus, demonstration software, and a unit called a test wiring concentrator, which forms the hub of a prototype token-ring network. You can connect as many as eight PCs, via the adapter cards and cables, to a concentrator. The concentrator provides traffic control for the ring, bypassing inactive stations and selecting active ones for ring communications. The concentrator's LED indicators let you know at a glance whether a station is inserted in the ring. You can add more PCs to the ring by chaining additional test wiring concentrators.



You can build, monitor, and analyze a token-ring network *using the TMS380 development tools. These products are the result of a joint development program between IBM and Texas Instruments.*

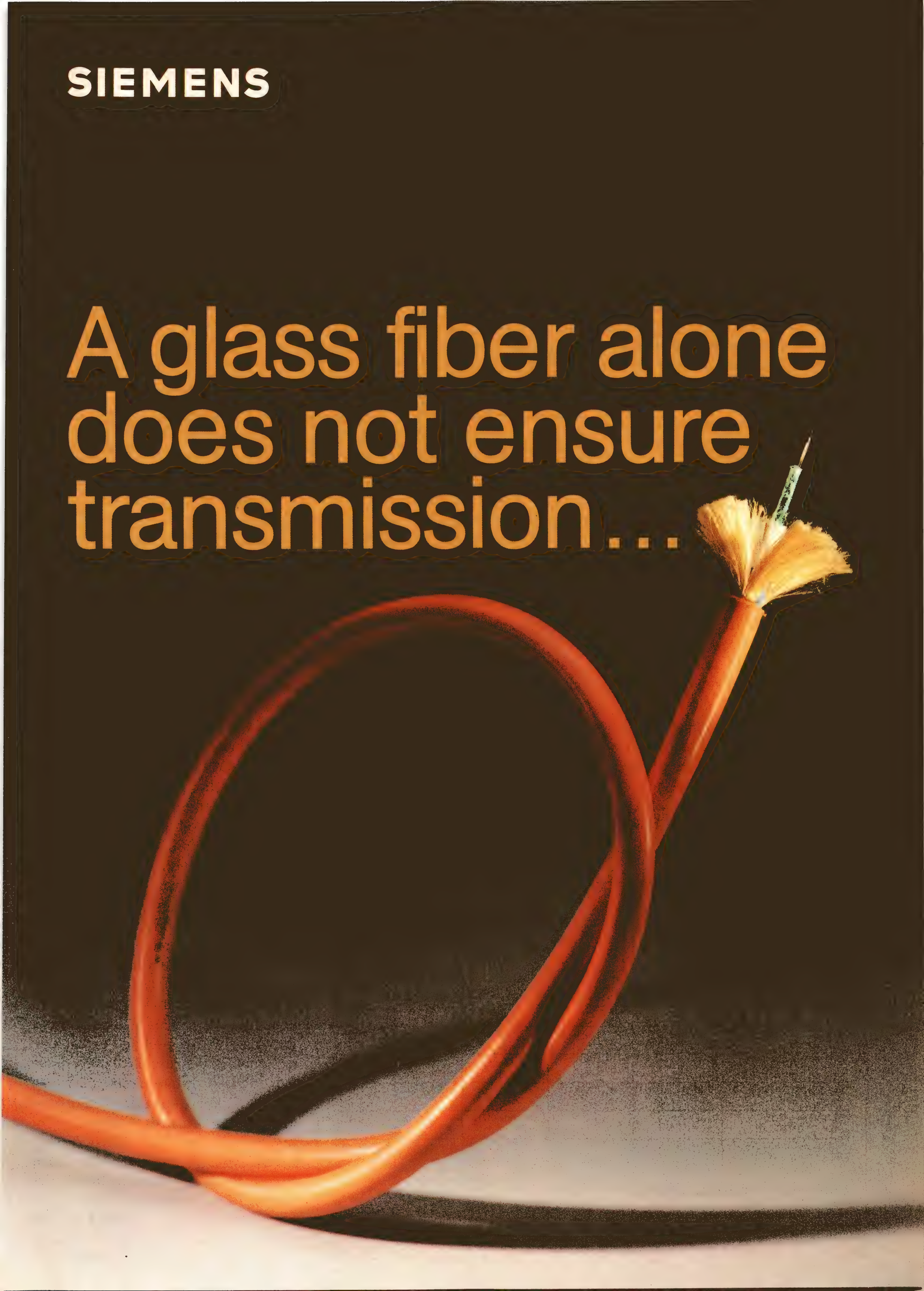
These TMS380 development tools support the manufacturer's previously announced TMS380 Design-in Accelerator Kit, which includes three of the manufacturer's token-ring LAN-adapter chip sets. That $1985 kit contains the hardware and debugging software needed to adapt three PCs for use on a token-ring LAN. With the kit and a test wiring concentrator, you can construct a 3-station token-ring LAN and then add a fourth PC with an adapter card to monitor and analyze the performance of the network.

You can use the TMS380 tools for system integration, communications protocol development, network traffic analysis, and performance testing. A "copy all frames" feature allows you to copy every frame of network traffic into the monitoring PC for analysis, a particularly helpful feature for the development of upper-level communications protocols, such as IEEE 802.2. You can initialize the adapter card to copy Media Access Control (MAC) frames, non-MAC frames, and information regarding the header type and frame length.

The PC adapter card features a software-controlled I/O interface. The PC/AT adapter card has a higher performance DMA interface. Both cards include 16k bytes of RAM, sockets for as many as 64k bytes of EPROM, and a socket for an address PROM. Adapter card and software, $1750. Test wiring concentrator, $1990.—***J D Mosley***

Texas Instruments Inc, Semiconductor Group, Box 809066, Dallas, TX 75380. Phone local office.

Circle No 732

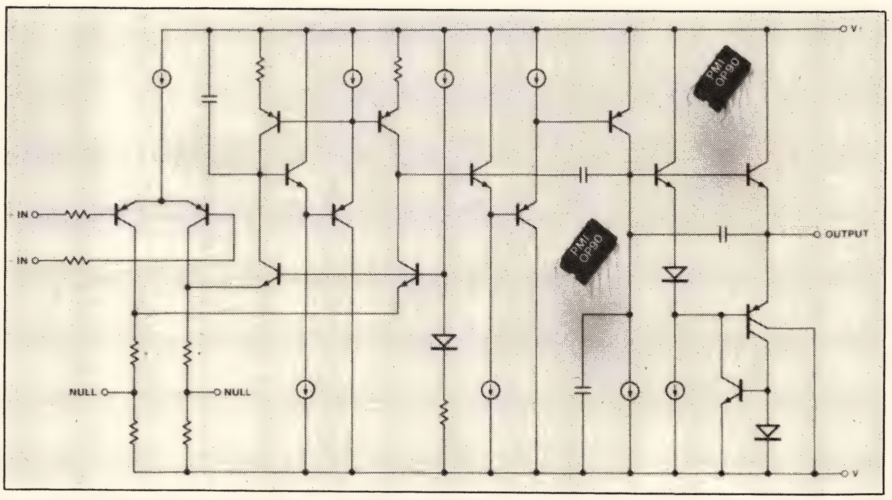

SIEMENS
A glass fiber alone does not ensure transmission...

Single- or dual-supply micropower op amp overcomes low-current-device shortcomings

The bipolar, micropower OP-90 operational amplifier draws only 20-μA max supply current and operates from single or dual supplies whose total span ranges from 1.6 to 36V. The OP-90 has the precision dc specs of the manufacturer's industry-standard OP-07 but consumes only 1% of the power used by the earlier device.

As **Table 1** indicates, the OP-90 doesn't sacrifice dc performance. The premium-grade OP-90E, for example, has very low offset voltage and drift, and its gain is 700,000 min when driving a 100-kΩ load (100,000 min for a 5-kΩ load). Common-mode and power-supply rejection ratios are 110 and 100 dB min.

Also notable are the OP-90's input-voltage range and input-overload capability. As you can see from **Table 1,** the input-voltage span for linear operation ranges from the negative supply voltage (ground for a single-supply system) to a level 0.8V lower than the positive supply voltage. Note that the output can also swing as low as ground in single-supply applications; the op amp thus provides true zero-in, zero-out capability.



Coupling precise dc performance with low power consumption, *the OP-90 operates from single or dual supplies and is a drop-in replacement for the industry-standard OP-07.*

TABLE 1—SALIENT SPECS FOR THE OP-90 MICROPOWER OP AMP

PARAMETER	OP-90A −55 TO +125°C	OP-90E −25 TO +85°C	OP-90F −25 TO +85°C	OP-90G 0 TO 70°C	UNITS
OFFSET VOLTAGE AT 25°C	150	75	150	300	μV MAX
OFFSET VOLTAGE OVER TEMPERATURE	350	135	330	540	μV MAX
BIAS CURRENT OVER TEMPERATURE	15	12	30	40	nA MAX
OPEN-LOOP GAIN R_L=100k	600	700	500	400	V/mV MIN
OPEN-LOOP GAIN R_L=5k	100	100	50	50	V/mV MIN
OUTPUT SWING R_L=100k	14.2	14.2	13.8	13.5	±V MIN
OUTPUT SWING R_L=5k	13.6	13.6	13.4	13.3	±V MIN
INPUT-VOLTAGE RANGE	−15 TO +14.2	−15 TO +14.2	−15 TO +14.2	−15 TO +14	V MIN
COMMON-MODE REJECTION RATIO	110	110	104	100	dB MIN
POWER-SUPPLY REJECTION RATIO	10	10	15	15	μV/V MAX

NOTE: SPECS ASSUME ±15V SUPPLIES.

Few IC op amps, whether they operate from single or dual supplies, can withstand input voltages that reach levels beyond the supply voltages. The OP-90, however, incorporates input protection to levels as high as 20V beyond either supply level. What's more, the protection is valid whether the power supplies are turned on or off.

The noise voltage for the OP-90 is a respectable 3 μV p-p, and the op amp's low (1-Hz) 1/f-noise corner frequency ensures a low value of low-frequency noise. Note that, in spite of its low power consumption, the OP-90 can deliver more than ±5-mA current to a load.

Be aware that the OP-90's low power consumption exacts its toll in speed performance. The amplifier's gain-bandwidth product is 25 kHz typ, and slew rate is 0.008V/μsec typ. Prices range from $2.75 to $14.90 (100), depending on grade and temperature range.

—Bill Travis

Precision Monolithics Inc, 1500 Space Park Dr, Santa Clara, CA 95052. Phone (408) 727-9222.

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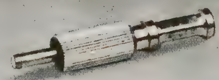

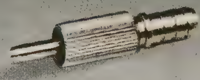

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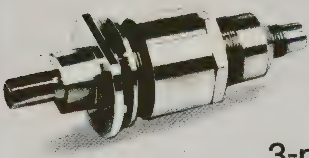
connectors to connect the optical waveguide.



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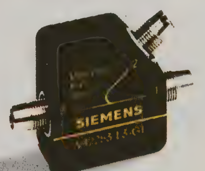

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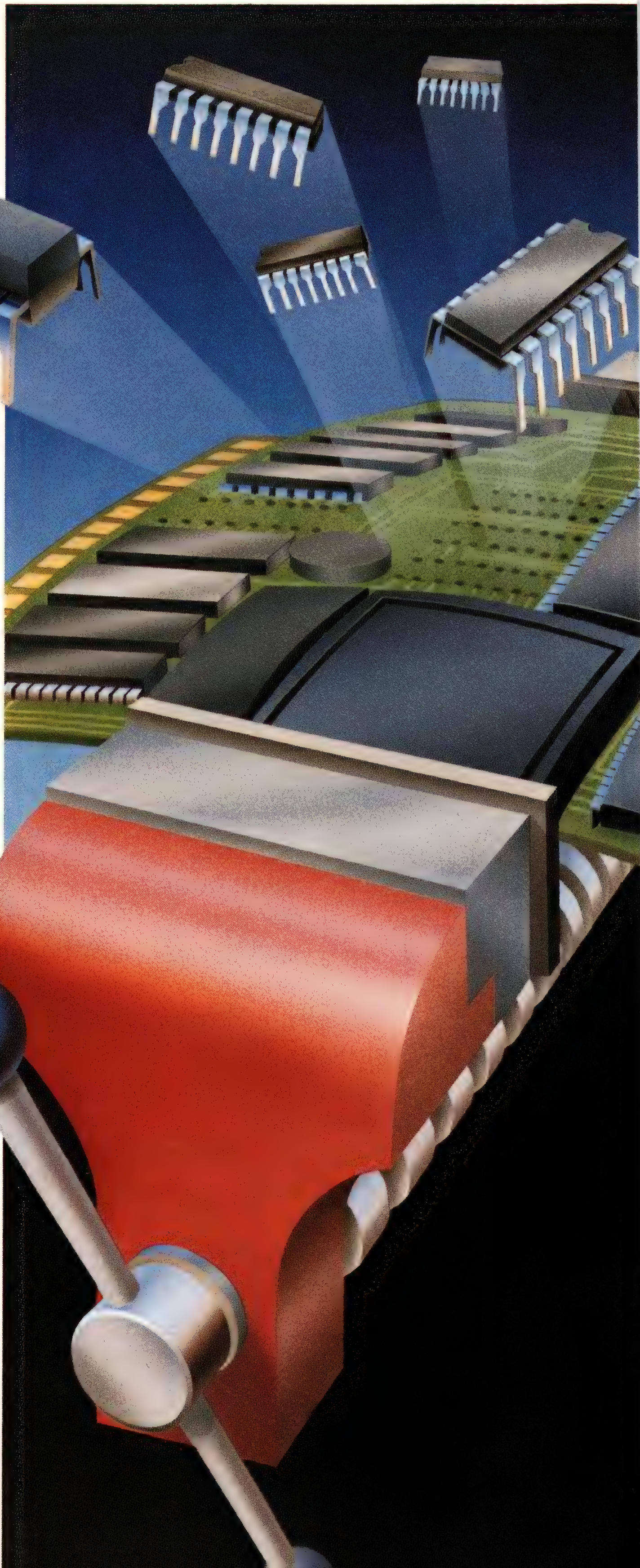

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256K SIMM Selection Guide

Device	ORG	Access Time (ns)	Cycle Time (ns)	Standby Power (mW)	Active Power (mW)	Package	Pins
MC41256A4	256K x 4	120 150	220 260	110 110	1825 1540	A/C	22
MC41256A5	256K x 5	120 150	220 260	140 140	2285 1925	A/C	24
MC41256A8	256K x 8	120 150	220 260	220 220	3655 3080	A/B	30
MC41256A9	256K x 9	120 150	220 260	250 250	4110 3465	A/B	30
MC411000A1	1M x 1	120 150	220 260	110 110	540 470	A/C	22

Package Designators: A — Ceramic Leaded, C — Glass Epoxy Leaded, B — Glass Epoxy Socketed.

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CIRCLE NO 58

401 Ellis Street P.O. Box 7241
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Monochrome graphics-display subsystem adds 1280×960-pixel monitor to PCs

When configured with the Viking 1 monochrome graphics-display subsystem, your IBM PC or compatible computer can run application programs that demand displays with 1280×960-pixel resolution. Although not software compatible with existing PC-bus display adapters, the Viking 1 can accept and digitize video signals from several available display adapters and display the digitized image on its monitor. You can use this feature to build single-monitor systems that have both high-resolution graphics and PC-display compatibility.

The subsystem includes a 110-MHz, monochrome, 19-in. monitor and an expansion card for the PC bus. A 66-Hz, noninterlaced display refresh rate provides a flicker-free image. The expansion card carries a 2M-bit display memory and a Hitachi HD63484 advanced CRT controller (ACRTC) for hardware drawing functions and screen control. Although the display memory is organized as a 1024×2048-pixel bit map, only a 960×1280-bit section appears on the monitor. You can use a 1024×768-bit area of the display memory for storing character fonts, figures, and display formats.

Existing PC display adapters can coexist with the Viking 1. A frame grabber on the Viking 1 accepts video signals from the IBM Color Graphics Adapter or Monochrome Display Adapter, or the Hercules monochrome graphics adapter via an external cable. The signals are digitized, and the resulting image is placed in the upper-left corner of the Viking 1 display in a 1:1 pixel/image transfer. The frame grabber has its own display memory and does not use the 2M-bit memory. You can choose between the digitized image and the Viking 1's display memory by programming a bit in the Viking 1's control register. Two jumpers allow you to configure the frame grabber for monochrome or color adapters.

Adding a 1280×960-pixel, monochrome graphics display to IBM PCs *and compatible computers, the Viking 1 graphics-display subsystem is based on the Hitachi HD63484 advanced CRT controller chip and includes a high-bandwidth, 19-in. CRT monitor.*

You also use jumpers to set the ACRTC base address. The Viking 1 requires a block of eight addresses between 200_{HEX} and $3FF_{HEX}$ for the ACRTC. A BIOS ROM, located at $DC000_{HEX}$, configures DOS and initializes the ACRTC, which provides intelligent control of the bit map. Hardware functions include arc, line, circle, and polygon drawing, as well as polygon filling and pan and zoom. The ACRTC acts as a PC Bus master, reading drawing instructions from and writing status information to the PC's main memory using DMA. The Viking 1 costs $2195.—***Steven H Leibson***

Moniterm Corp, 5740 Green Circle Dr, Minnetonka, MN 55343. Phone (612) 935-4151.

Circle No 734

Process controllers operate in networks at distances of 1000 ft between nodes

Each member of the DS-20 Series of distributed process controllers supplies intelligent control for eight analog inputs, eight analog outputs, and 24 configurable digital I/O lines. You interconnect these systems over an enhanced, optoisolated RS-232C interface. You can place 32 DS-20 nodes in a network, with each node as much as 1000 ft from any other. A DS-20 unit communicates with a host computer or terminal via a second RS-232C port.

The eight analog outputs have an output voltage range of 0 to 10V and are driven by 8-bit D/A converters. The eight differential analog inputs are multiplexed into a 12-bit A/D converter. This D/A converter performs 7.5 conversions/sec, which helps the system reject 60-Hz noise. Analog inputs are filtered to reject noise above 100 kHz, and analog inputs and outputs alike are protected from voltage transients above 17V and energy transients of 1.5 kW.

Because it provides eight differential analog inputs, *eight analog outputs, and 24 digital I/O channels, you can program the DS-20 controller for a variety of tasks. You can also configure 32 DS-20s in a process-control network, with 1000 ft of cable between nodes.*

In the standard DS-20, all 24 digital I/O lines are configured as 5V dc inputs with 100-kHz lowpass noise filters. Add-on modules allow you to reconfigure any of the digital I/O lines individually. Available input modules include a 12/15V dc module and three ac/dc input modules for 24, 115, and 220V inputs. The ac/dc modules cost $28 each, and the 12/15V dc module costs $8.11. Input modules are protected from voltage and energy transients. Two digital output modules allow you to configure digital I/O lines as output channels. An open-collector, 5 to 15V, 500-mA output module costs $9.60, and a relay-based, 24 to 240V, 1A ac/dc output module costs $42.

You program the DS-20 for closed-loop process-control tasks by means of the unit's built-in Ace language. Ace is a Forth-like, threaded interpreter and operating system with extensions tailored for the DS-20's hardware resources, which include a battery-backed clock/calendar. Language extensions for network control allow you to communicate from the host CPU or terminal to each controller on your network individually or to all controllers in parallel. This last feature allows you, for example, to command all DS-20s to simultaneously read a voltage on the same analog input channel.

Procedure definitions in Ace are called words, and you can define words in terms of other previously defined words to create complex programs. Ace supports relocatable words so you can store definitions in the DS-20's 8k-byte EEPROM once you have debugged them in RAM. If you define a word called "START-UP" and store it in the EEPROM, that word will be executed upon power-up and give the DS-20 the ability to operate autonomously from the host, once programmed. Ace executes both foreground and background tasks, allowing the controller to run the process-control program in background while interacting with the host CPU and network in foreground.

You can configure the DS-20's power supply for either 115 or 220V ac operation. The standard DS-20 costs $1125.—***Steven H Leibson***

Advanced Energy Industries Inc, 1600 Prospect Pkwy, Fort Collins, CO 80525. Phone (303) 221-4670.

Circle No 733

What the Japanese taught us about electronic design.

These days, everything is getting packed together tighter than it used to be.

And while the Japanese came up with the Oshiya for packing subways, Racal-Redac came up with an elegantly integrated CAE/CAD system specifically designed for packing electronic designs with things like SMDs, fine line gridless 100% routing, and mounting components on both sides of the board.

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CIRCLE NO 59

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Device	Access Times	Max Power (mW) act	stby	Process
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IMS1420 4K x 4	45,55	605	165	NMOS
IMS1423 4K x 4	25,35,45	660	33 CMOS	CMOS
IMS1600 64K x 1	45,55,70	440	77 CMOS	CMOS
IMS1620 16K x 4	45,55,70	440	77 CMOS	CMOS

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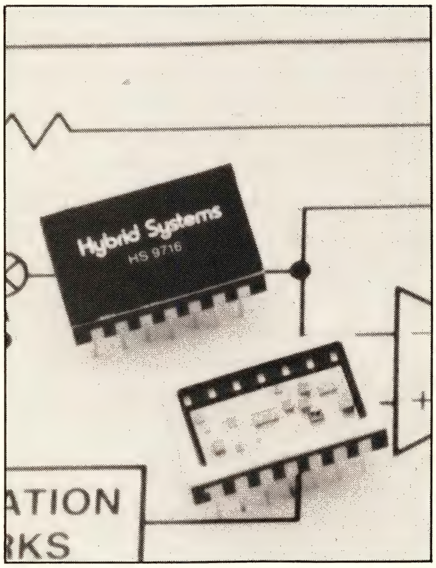
CIRCLE NO 60

inmos®

Hybrid S/H-amplifier series specs accuracies to 16 bits

The HS9716 and HS9714 hybrid-circuit sample/hold amplifiers use dielectric-absorption compensation for their internal hold capacitor. Dielectric absorption is a mechanism whereby a capacitor "remembers" a portion of a previously applied voltage, despite the application of a new voltage level. This phenomenon is one of the major factors limiting the accuracy of S/H amplifiers. The compensation scheme employed in the HS9716 and HS9714 makes the devices suitable for use in 16- and 14-bit analog data-acquisition systems, respectively.

Figures for the 16- and 14-bit dielectric-absorption compensation are 7.5 and 15 µV/V max, respectively. These specs apply to any step (as high as 20V) in the units' ±10V input range, and they correspond to ½-LSB error at 16 and 14 bits, respectively. Typical gain-linearity specs are ±0.0005% for the HS9716 and ±0.001% for the HD9714.



***Compensation for dielectric absorption** in the hold capacitor makes the HS9716 sample/hold amplifier suitable for analog data acquisition in 16-bit-linear systems. You can use the device with any 16-bit-linear A/D converter; its companion, the HS9714, is suitable for use with any "16/14" (16-bit-resolution, 14-bit-linear) A/D converter.*

The closest rival to the HS9716/9714 Series is the pin-compatible AD389. The specs for this device, however, do not encompass the ±½-LSB error band associated with 16 bits of resolution (½ LSB is 0.0008%). For example, both HS types specify a 10-µsec max acquisition time to ±0.0008%; the AD389 has no spec for this error band. Instead, the AD389 has (as do the HS9716/9714 parts) a 5-µsec max acquisition time to ±0.003%, which equals ±½ LSB at 14 bits.

Additional comparisons with the AD389 put the HS units in a favorable light. The noise figure in the tracking mode for the AD389 is 200 µV rms; for the HS9716/9714, it's 20/50 µV rms. Droop for the HS9716 and 9714 is 0.05 and 0.1V/sec max, vs the AD389's 1V/sec max. Feedthrough rejection for the HS devices is 98 and 90 dB min, vs the AD389's 74 dB min. Finally, the HS units offer the cited spec for dielectric-absorption compensation; the AD389 has no spec for this attribute.

Both the HS9716 and HS9714 come in 14-pin ceramic DIPs and are available for operation over the temperature ranges 0 to 70°C and −55 to +125°C. For these two ranges, the HS9716 costs $150 and $79 (100), respectively; the HS9714 costs $130 and $69. The devices are available with screening to MIL-STD-883C, levels B or S.

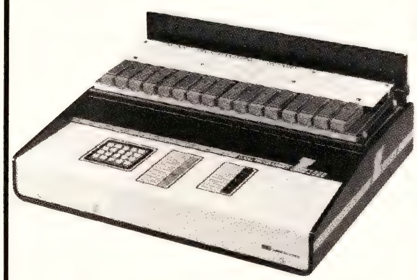
—Bill Travis

Hybrid Systems Corp, 22 Linnell Circle, Billerica, MA 01821. Phone (617) 667-8700.

Circle No 735

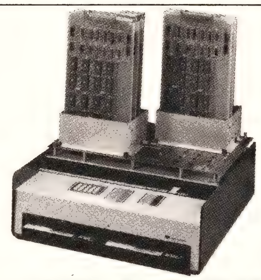
CIRCLE NO 61

AMERICA'S BEST PROGRAMMERS



Z-3000 HIGH VOLUME GANG/SET PROGRAMMER

- 14,000 27256s programmed per day.
- 32 EPROMs simultaneously with 1 to 8 DATA BLOCKS.
- 16 Intel or Motorola MCUs at a time.
- 64K to 256K bytes of DATA RAM.
- Simple one key programming operation.
- Two RS-232 ports with data transfer formats included.



Z-2500B IN-CIRCUIT MEMORY CARD PROGRAMMER

- Programs up to 32 memory cards with EPROMs or microcomputers at a time.
- Two 1.2 Mbyte DSDD floppy disk drives. Optional 20 Mbyte hard disk.
- Turnkey systems include programmer, terminal, custom interface hardware and software.
- Simple menu driven operation.

Z-1000B UNIVERSAL PROGRAMMER

- Over 600 PLDs, EPROMs, EEPROMs, bipolar PROMs and INTEL MCUs.
- Upgradeable PROM based software.
- Stand alone or PC/XT/AT operation.
- Two independent RS-232 ports.
- 64K or 256K bytes of DATA RAM.
- EXATRON handler interface is standard.

Z-1200B TWELVE SOCKET GANG/SET PROGRAMMER

- 2716-27512, 1 to 4 DATA BLOCKS.
- 64K to 256K bytes of DATA RAM.
- Software personality. No plug-ins.

ZAP SERIES low cost programmers for EPROMs and single-chip MCUs.

Z-400 for bipolar PROMs and EPROMs.

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Glendora, California 91740
(818) 914-1926

PWM kilowatt dc amplifier allows slaving to 30 kW

A modular, dc-coupled amplifier that measures 7.7×12.9×2.25 in. delivers 1.1 kW of continuous power (±15A at ±75V) and 1.6 kW of peak power. Model 220-10 uses pulse-width modulation (PWM) and a bridge-connected power-MOSFET output stage to hold internal dissipation down to 84W at full load. The unit's power efficiency is thus 92%.

You can connect amplifiers in parallel in a master/slave configuration to deliver 30 kW of continuous output (±450A at ±75V) or 48 kW peak. The amplifier's high (80-kHz) PWM switching rate is responsible for the unit's 10-kHz frequency response; this high switching frequency also simplifies the design (and reduces the size) of the internal filter needed to smooth the 80-kHz output pulses into an amplified replica of the amplifier's input. The 80-kHz output ripple is less than 1% at full load.

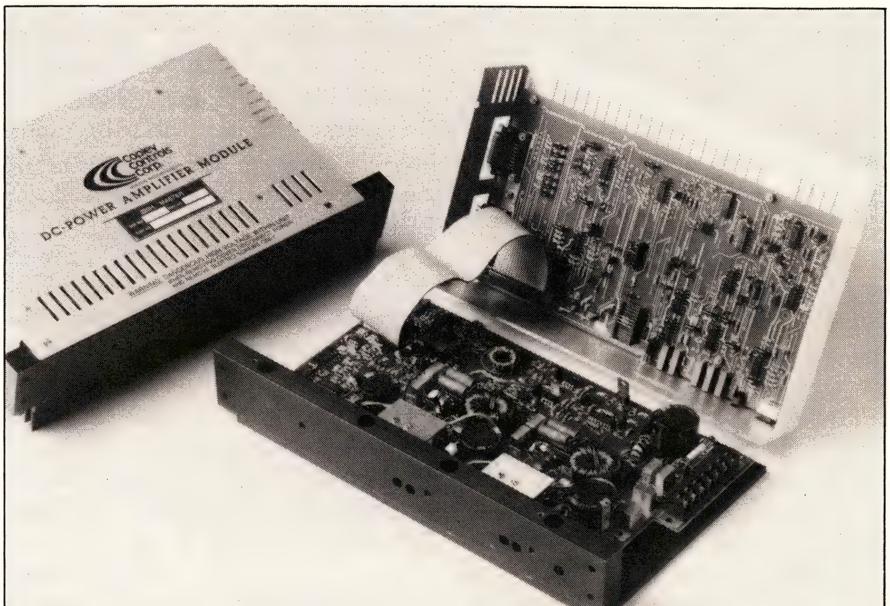
The output's power-MOSFET bridge uses a proprietary circuit that eliminates the crossover deadband inherent in many PWM amplifiers. Eliminating this deadband results in low distortion specs: 0.05% linearity from dc to 700 Hz and 1% total harmonic distortion from dc to 10 kHz.

Because of its high efficiency, the amplifier can operate over 0 to 60°C with no power derating. Built-in fault-detection/protection circuitry protects the amplifier against damage from overloads, short circuits, or excessive temperature rise.

Model 220M-10, the master unit, costs $1060 and can control as many as 30 slaves. Slave unit 220S-10 costs $975.—***Bill Travis***

Copley Controls Corp, 375 Elliot St, Newton, MA 02164. Phone (617) 965-2410.

Circle No 736



This telephone-book-sized PWM amplifier is 92% efficient. *It provides 1.1 kW of continuous output power. To obtain 30 kW of load power, you can connect as many as 30 units in a master/slave configuration.*

CIRCLE NO 62

Harris technology explodes inflated boards.

Low-cost, space-saving, channel selectable op amps simplify system designs.

In analog design, the goal is not bigger boards but better ones. And nothing accomplishes this goal like Harris channel selectable op amps.

The HA-2400 family combines the functions of an analog multiplexer and a high-performance quad op amp on one chip. Each device features four op amp inputs which can be individually connected to one output stage.

The result: improved system reliability, uncommon design versatility and dramatic savings in board space, design time and system costs.

The 2400 family utilizes our proven Dielectric Isolation technology to deliver some impressive specs:

- 30 V/μs slew rate
- 40 MHz gain bandwidth product
- 110 dB crosstalk rejection
- Digital channel selection - TTL compatible

The HA-2400 family is available in military (HA-2400), industrial (HA-2404), and commercial grades (HA-2405 and HA-2406). The new HA-2406 features the lowest cost. Use them to select and condition different input signals. Or choose different op amp functions to be performed on a single input signal.

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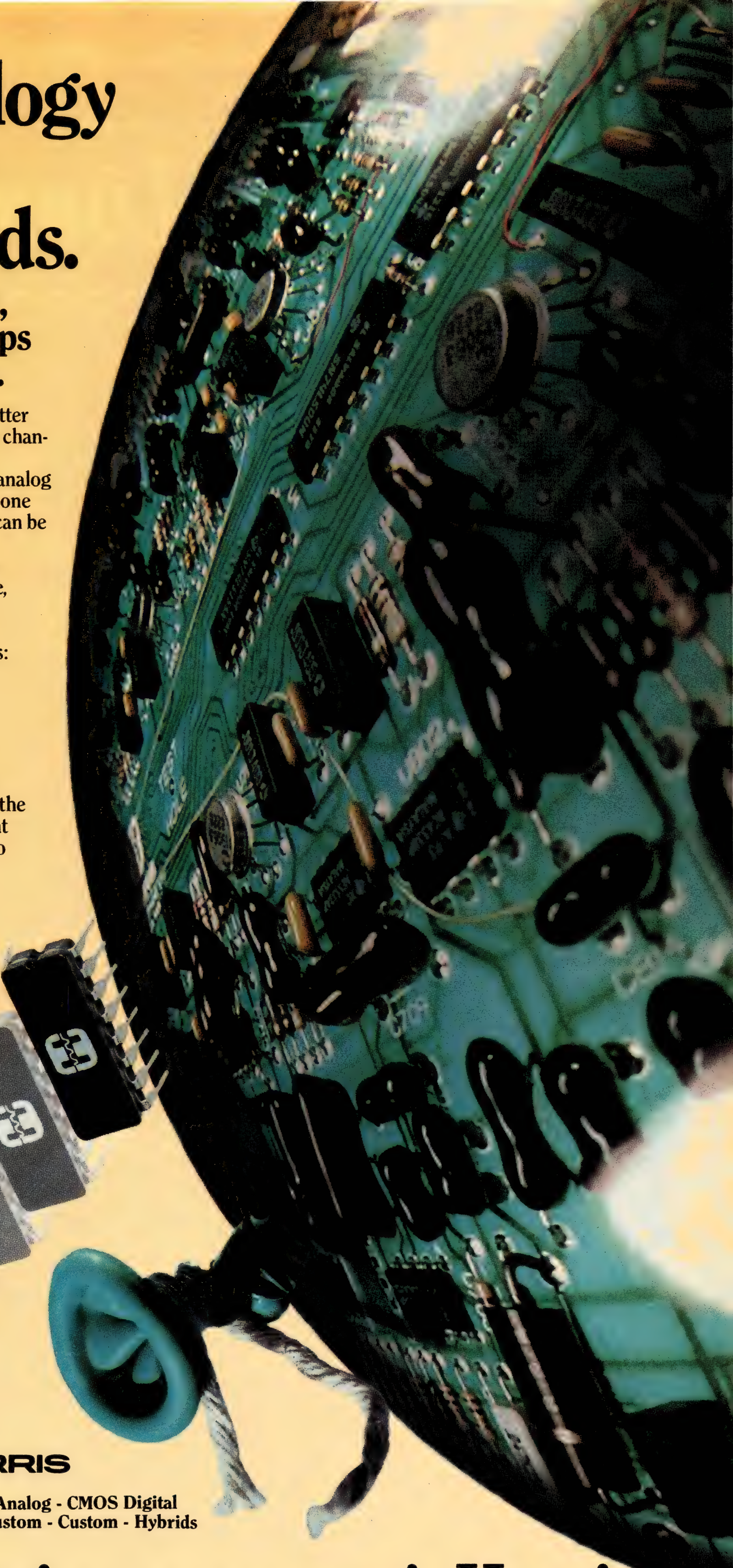
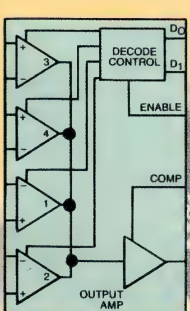
Contact: Harris/MHS
Semiconductor Sales Ltd.,
Eskdale Road, Winnersh,
Wokingham, Berks,
RG11 5TR, England.





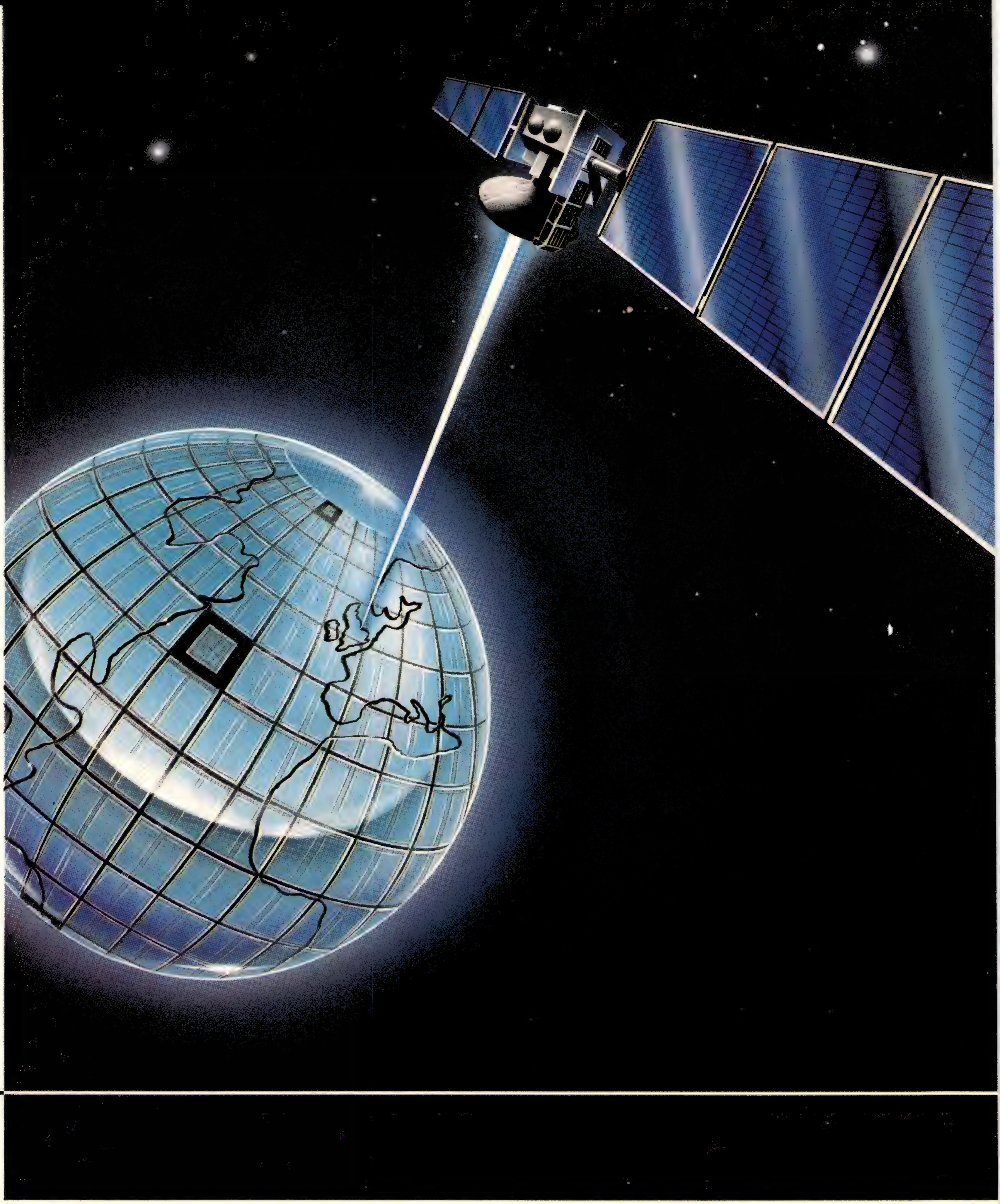
HARRIS

Harris Semiconductor: Analog - CMOS Digital
Gallium Arsenide - Semicustom - Custom - Hybrids

For your information, our name is Harris.

CIRCLE NO 63

Marconi, Lincoln, England



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For a technology which fully meets the demanding environmental requirements of deep space, and also the enhanced reliability needed for complex electronic systems, Silicon-on-Sapphire and Marconi offer the total solution.

Silicon-on-Sapphire	Semi-custom cell array		Ram
Feature size	5/3μm now	1.5/1μm Q4 '87	3μm now
Total dose Neutron – n/cm^2 (1 MeV) Ionising – Rad (Si)	10^{15} 10^{6}	10^{15} 10^{7}	tba $>10^{5}$
Single event upset (soft errors) – errors/bit-day	10^{-9}	3×10^{-10}	$<10^{-8}$
Transient upset – rad (Si)/sec	10^{10}	10^{11}	$>10^{9}$
Latch-up	none	none	none

Cellsos	Now	End '87
Feature size	3μm	1μm
Maximum gates	4,300	36,000
Gate delay (2 loads and 1mm metal)	2nS	0.5nS
D-type toggle frequency	40 MHz	160 MHz
Supply voltage	3-8V	1.5V-3V
Power – μW/MHz/Gate	2	0.08

For further information, please contact Alan Ball on (England) 0522 688121.

Marconi
Electronic Devices

Lincoln Industrial Park, Doddington Road,
Lincoln LN6 3LF, United Kingdom
Tel: 0522 68121

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Last year we introduced our MetaICE™-31 and MetaICE™-51 families of low cost real time emulators. Engineers soon found that they did provide more support for the MCS®-51 family of microcontroller chips, just as we said. With more ease of operation and at prices that are affordable.

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CIRCLE NO 65

Our Trace Option is the ICE-ing

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LEADTIME INDEX

Percentage of respondents

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
TRANSFORMERS								
Toroidal	7	22	57	14	0	0	7.2	11.3
Pot-Core	8	23	46	23	0	0	7.8	9.3
Laminate (power)	0	14	72	14	0	0	8.3	8.4
CONNECTORS								
Military panel	10	30	50	10	0	0	6.2	8.0
Flat/Cable	26	42	21	11	0	0	4.3	3.5
Multipin circular	13	20	47	13	70	0	8.1	7.6
PC	13	50	31	6	0	0	4.4	4.5
RF/Coaxial	13	53	20	7	7	0	5.6	5.6
Socket	29	48	14	9	0	0	3.5	3.4
Terminal blocks	17	46	29	8	0	0	4.5	3.7
Edge card	11	53	31	5	0	0	4.3	4.4
Subminiature	7	36	50	70	0	0	5.8	2.8
Rack & panel	10	40	40	10	0	0	5.6	5.6
Power	27	46	27	0	0	0	3.1	6.9
PRINTED CIRCUIT BOARDS								
Single-sided	0	65	35	0	0	0	4.1	4.1
Double-sided	0	50	50	0	0	0	5.0	5.0
Multilayer	0	47	47	6	0	0	5.7	9.8
Prototype	10	80	10	0	0	0	2.4	2.0
RESISTORS								
Carbon film	32	36	28	4	0	0	3.6	3.0
Carbon composition	29	29	38	4	0	0	4.3	5.2
Metal film	36	32	29	3	0	0	3.4	3.0
Metal oxide	21	36	43	0	0	0	4.2	3.7
Wirewound	22	35	35	8	0	0	4.9	4.7
Potentiometers	31	35	25	9	0	0	4.1	5.2
Networks	42	37	21	0	0	0	2.4	5.2
FUSES	57	17	17	9	0	0	3.1	2.5
SWITCHES								
Pushbutton	34	33	22	11	0	0	4.2	4.7
Rotary	13	20	47	20	0	0	7.4	7.3
Rocker	25	34	33	8	0	0	4.6	6.3
Thumbwheel	8	59	25	8	0	0	4.5	9.8
Snap action	33	33	20	14	0	0	4.9	5.3
Momentary	7	57	22	14	0	0	5.1	5.8
Dual in-line	10	60	20	10	0	0	4.4	5.6
WIRE AND CABLE								
Coaxial	39	59	11	0	0	0	1.9	3.2
Flat ribbon	45	36	14	5	0	0	2.6	1.6
Multiconductor	38	33	29	0	0	0	3.0	2.4
Hookup	58	32	10	0	0	0	1.4	1.7
Wire wrap	72	14	7	7	0	0	2.0	2.7
Power cords	27	32	32	9	0	0	4.6	3.2
Other	25	12	50	13	0	0	6.3	2.4
POWER SUPPLIES								
Switching	0	41	47	12	7	0	6.5	8.4
Linear	6	50	25	19	9	0	6.0	8.7
CIRCUIT BREAKERS	6	35	30	29	0	0	7.7	7.8
HEAT SINKS	23	41	24	12	0	0	4.7	6.0

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
RELAYS								
General purpose	29	24	33	14	0	0	5.4	5.0
PC board	13	27	33	27	0	0	7.5	7.6
Dry reed	0	46	36	18	0	0	6.7	6.0
Mercury	0	50	38	12	17	0	6.0	9.0
Solid state	9	18	46	27	8	0	8.3	8.8
DISCRETE SEMICONDUCTORS								
Diode	29	32	26	13	0	0	4.8	5.5
Zener	34	31	21	14	0	0	4.5	4.8
Thyristor	24	29	29	18	0	0	5.8	6.1
Small signal transistor	31	17	35	17	0	0	5.9	5.7
FET, MOS	24	18	35	18	5	0	7.3	12.6
Power, bipolar	22	7	50	21	0	0	7.5	8.1
INTEGRATED CIRCUITS, DIGITAL								
CMOS	20	32	32	16	0	0	5.8	7.4
TTL	22	30	26	22	0	0	6.2	9.0
LS	33	19	24	24	0	0	6.1	8.3
INTEGRATED CIRCUITS, LINEAR								
Communication/Circuit	0	20	60	20	0	0	8.4	9.8
OP amplifier	10	32	37	21	0	0	7.0	8.1
Voltage regulator	14	34	33	19	0	0	6.4	7.2
MEMORY CIRCUITS								
RAM 16k	7	40	20	33	0	0	7.7	8.0
RAM 64k	26	32	16	26	0	0	8.7	6.2
RAM 256k	7	29	43	21	0	0	7.4	7.8
ROM/PROM	8	17	42	33	0	0	9.0	8.0
EPROM	18	41	18	23	0	0	5.9	6.5
EEPROM	8	25	42	25	0	0	7.9	9.1
DISPLAYS								
Panel meters	0	46	45	9	0	0	6.0	5.6
Fluorescent	0	0	57	43	0	0	11.4	6.5
Incandescent	0	37	38	25	0	0	7.8	5.6
LED	14	45	27	14	0	0	5.3	6.2
Liquid crystal	13	25	50	12	0	0	6.4	8.3
MICROPROCESSOR ICs								
8-bit	26	26	32	11	5	0	6.1	6.4
16-bit	19	19	50	6	6	0	6.9	11.3
FUNCTION PACKAGES								
Amplifier	18	9	46	27	0	0	8.2	6.2
Converter, analog to digital	7	29	43	21	0	0	7.4	7.2
Converter, digital to analog	9	18	46	27	0	0	8.4	8.6
LINE FILTERS	18	9	55	18	0	0	7.5	7.4
CAPACITORS								
Ceramic	34	33	26	7	0	0	3.9	3.9
Ceramic monolithic	25	42	25	8	0	0	4.1	4.4
Ceramic disc	35	22	30	13	0	0	4.9	4.2
Film	14	33	43	10	0	0	5.7	6.3
Electrolytic	21	21	42	12	4	0	6.7	6.0
Tantalum	26	26	33	11	4	0	6.0	6.2
INDUCTORS	18	23	47	12	0	0	6.1	6.3

Source: *Electronics Purchasing* magazine's electronics business survey

The high-performance, high-density interconnect for today's tighter budgets.

Hardworking Ds, from AMP.

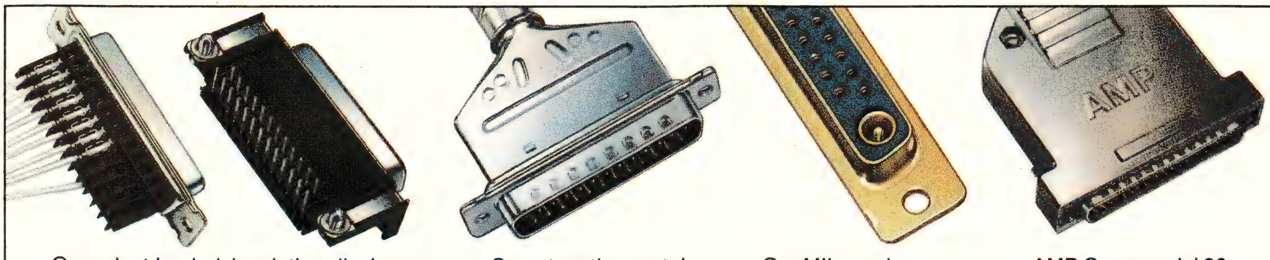
One of the latest additions to this giant family of space-savers offers pre-loaded, insulation-displacement contacts for mass termination.

Save on application costs. And save more with select loading, by paying only for the contacts you intend to use.

Our Ds also come with a range of shielding options to block EMI/RFI, including full metal cable clamp assemblies or lightweight (and low cost) metalized plastic housings. We even offer a snap-together "generic" shell designed to allow postmolding your own housing.

Other D-lights? Our high-density Commercial 90 Series uses a smaller-size contact, to pack more circuits in. And we offer our MIL-series coax and power contacts in a broad range of configurations, to pack more functions in as well.

Find out now how selection, performance, and total economy can help you keep your budget in trim. Give us a call.



Our select-loaded, insulation-displacement RS 232 style—with the recently introduced board mount with grounding strap, 440 threaded inserts, and board locks.

Snap-together metal shields block EMI, allow you to postmold your own housings.

Our MIL-version subminiature Ds come with optional power and coax contacts, in a variety of configurations.

AMP Commercial 90 connectors, through the use of smaller pin-and-socket contacts, offer almost double the density of standard Ds.

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AMP **Interconnecting ideas**

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CIRCLE NO 66

We're selling the

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We're proud of the success we've had supplying leading microsystem builders with disk controller boards.

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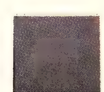
The pace is quickening. Our chip engineers have been busy. Right now we're introducing new VLSI devices at an especially rapid pace.

That includes more highly integrated hard and floppy disk controllers, both with on-board data separators. (Neat trick, huh?) A single

WD1002A-WX1
4.95" x 3.85" half-slot IBM XT compatible controller for up to two ST506 drives.

WD30C30/31
CMOS ST506/RLL Hard disk controllers with on-chip ECC and analog data separator.



***WD3600** CMOS streaming drive controller with QIC-36 interface.*

secret to our success.

chip controller that turns SCSI from scuzzy to sexy. A new QIC-36 streaming tape controller device. And an RLL hard disk controller with 56-bit ECC.

Our board engineers have been busy too. Integrating our new VLSI into solutions that address the emerging high performance disk markets of (2, 7) RLL and ESDI, as well as new technologies such as optical.

Up the function. Down the cost.

Being our own biggest customer for our VLSI devices has taught us a lot about what our chip level customers need and want.

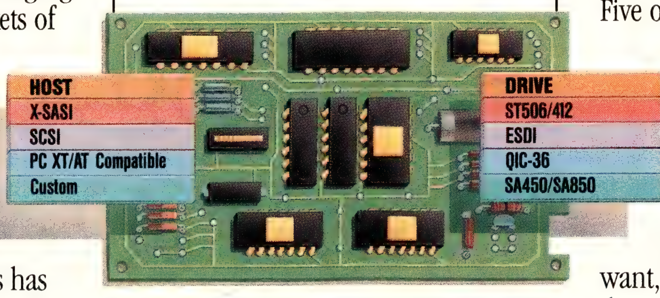
Such as devices that are easy to design with and easy to test. And that have a built-in promise of follow-on solutions that drive down the cost of your system design and manufacturing costs by giving you more for less.

No secrets.

Our VLSI devices come with systems level support, to help you get to market quickly. Because we design our devices with system issues in mind, and sort out design considerations for our own board-level products, we can help you integrate our devices into your system.

As a matter of fact, start with our board-level solutions, for accelerated market entry and reduced start-up cost, and we'll help you build your own boards based on our chips as soon as you're ready. We'll even license our microcode, saving you man-years of development time and hard-knocks experience.

That promise is backed with more technical people working on-site with customers than any controller manufacturer in the world. And more in-house applications engineers that live and die by the motto, "we succeed when you succeed."



Choose your interface. Our VLSI solutions provide the foundation for a family of boards supporting all popular host and drive interfaces.

Make our success yours.

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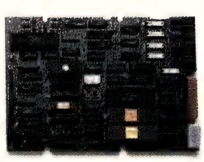
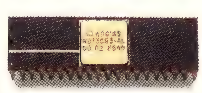
WESTERN DIGITAL
C O R P O R A T I O N

WD5011-10 ST506 Hard disk controller/formatter using 2, 7 RLL encoding and on-chip 56-bit ECC.

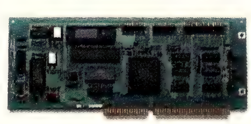
WD37C65 CMOS Floppy disk controller with on-chip digital data separator. NEC765A compatible.



WD1005-SCS SCSI interface controller for up to four ESDI drives with powerful 56-bit ECC.



WD33C93 CMOS SCSI bus interface controller with on-chip high current drivers.



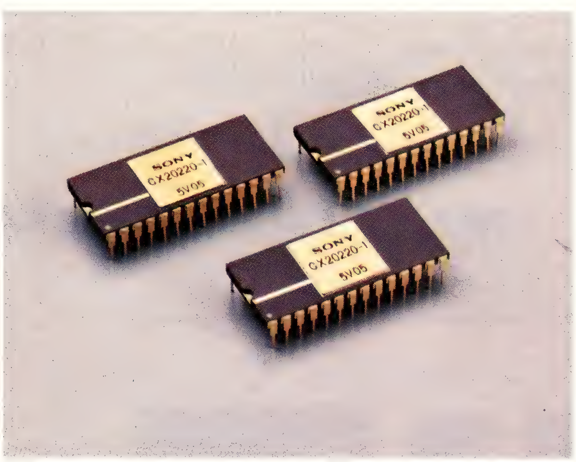
WD1003-WAH 100% PC AT compatible hard disk controller for up to two ST506 drives.

CIRCLE NO 67

You can upgrade the performance of many electronic systems simply by replacing such systems' data converters with better ones. And regardless of your application, you have many parts to choose from. Because they are such vital components, data converters have remained the focus of intense development for years.

Analog/digital and digital/analog data converters

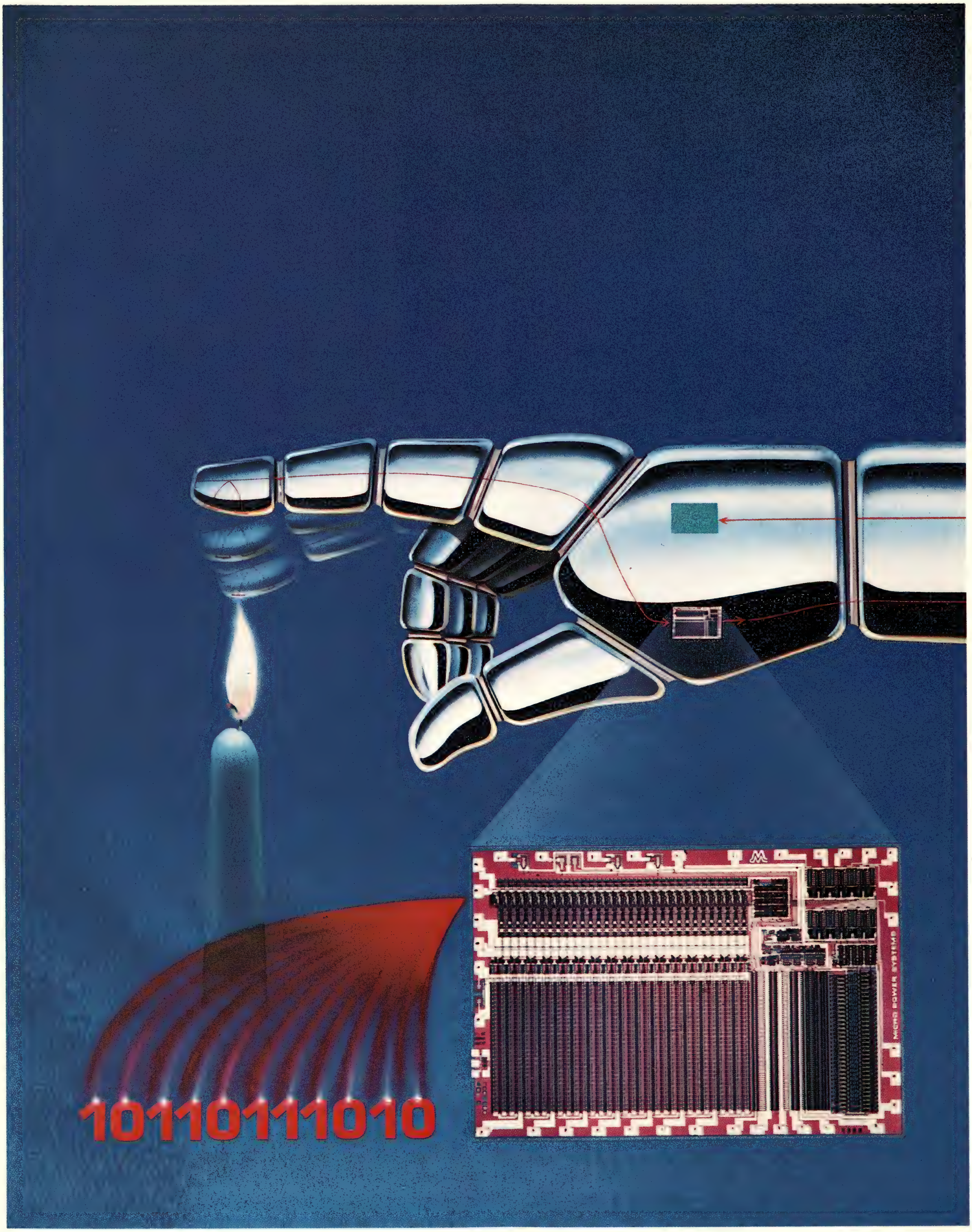
Tarlton Fleming, *Associate Editor*



This monolithic subranging A/D converter, *the CX20220-1 from Sony, provides 10-bit resolution and a 20M-sample/sec word rate.*

Data converters continue to develop in directions dictated by the applications they serve. Since EDN's last special report on converters **(Ref 1),** 16-bit monolithic DACs have become commonplace. Designers continue to achieve faster conversion times by refining the venerable successive-approximation A/D converter, and the parallel or subranging flash converter based on high-density CMOS processes promises to expand its domain of applications, simply by offering benefits you can't resist: small size, low power, high speed, and high resolution.

Today's converter manufacturers are pressed by escalating demands from OEMs in such fields as digital signal processing, computer-aided tomography, robotics, process control, and image processing. As these applications and others demand more performance, manufacturers respond with faster, more accurate, higher-resolution converters. Whether as a side effect or by design, these products often cost less, occupy less space, and consume less power than their predecessors. At the same time, the evolution of IC process technologies is allowing converter makers to



The high speeds and high resolutions *of the latest A/D converters are much in demand by robotics and other sophisticated applications. (Photo courtesy Micro Power Systems Inc)*

This hybrid 12-bit, 1M-sample/sec A/D converter, *the IT 5245 from Intech, uses a 2-pass subranging conversion technique.*

Suitable for digital-audio applications, *Burr-Brown's monolithic PCM54 D/A converter provides 16-bit resolution and 0.0025% max total harmonic distortion.*

add more peripheral functions, both in monolithic and hybrid converter products.

The result of continued focus on these vital components has been a vigorous flow of new-product introductions in the past year. And the concentrated converter-development effort in many companies shows no sign of leveling off; if anything, hints from company spokespersons suggest that the rate of product introductions will accelerate in the months ahead. What's more, the activity has been considerable in all subcategories of data converters, including monolithic, vertically integrated converter products; high-resolution sampling converters; general-purpose D/A converters; high-performance hybrid, modular, and monolithic A/D converters; integrating A/D converters; and D/A converters for video applications.

As a simple, common example of the vertical integration of functions, a manufacturer takes the sample/hold amplifier that usually precedes an A/D converter's input, installs it in the converter package, and then specifies performance for the two as a unit, which manufacturers call a sampling converter. Besides saving space, these sampling converters eliminate the need to analyze many of the S/H amplifier's error contributions. The variety of low-end products in this category shows a continued strong demand for μP-compatible 8-bit A/D converters.

Among the new monolithic sampling converters is Analog Devices' 8-bit AD7575. Built from the company's BiMOS II process, which combines CMOS logic with precision linear functions on the same chip, the device can accurately digitize a 50-kHz sine wave while dissipating only 15 mW. Other members of this family that are half-flash converters but *not* sampling converters include the 1.36-μsec AD7820; the 2.5-μsec AD7824 with a 4-channel input multiplexer; and the 2.5-μsec AD7828 with an 8-channel multiplexer. These parts are all 8-bit monolithic devices, fabricated in the BiMOS II process. One other new part that's neither a half-flash nor sampling converter is the 10-μsec AD670; that 8-bit bipolar successive-approximation ADC comes in a 20-pin DIP and features 3-state outputs, an instrumentation amplifier, and a bandgap reference.

Analog Devices' development of the BiMOS II process is part of a worldwide effort by many companies to merge analog-bipolar and digital-CMOS circuits on the same die. These mixed analog/digital processes find direct use in application-specific ICs, and their future

Today's converter manufacturers are pressed by the demands of digital signal processing, computer-aided tomography, robotics, and other applications.

seems assured by the prospect of increasing use for these processes in high-volume memory and logic ICs as well. Although the process as used in early products of this type was complex and expensive, the industry is moving toward versions that require only a few additional manufacturing steps.

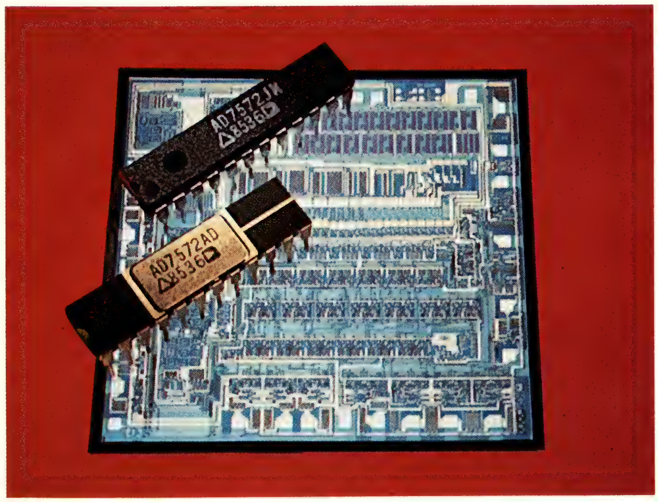
Converter chip includes S/H amplifier

Also in the half-flash A/D-converter category is National Semiconductor's 8-bit CMOS ADC0820, in which the input sampled-data comparators provide an S/H-amplifier function for input slew rates less than 100 mV/μsec. The part offers a conversion time as short as 1.5 μsec, and it can accurately measure a 7-kHz, 5V p-p sine wave without an external S/H amplifier.

Telefunken and Texas Instruments also offer 8-bit sampling converters. Telefunken's U3009M is an n-channel MOS device with serial and parallel outputs, a 160-μsec conversion time, and 550-mW max power dissipation. It operates from a 5V supply. TI's linear-CMOS (LinCMOS) TLC548 features an 8-bit switched-capacitor successive-approximation A/D converter, an S/H amplifier, and serial data output. Housed in an 8-pin mini-DIP, this converter dissipates about 27 mW. The manufacturer specifies that the device can generate a new output every 22 μsec.

Siliconix and TI have gone a step further by offering CMOS chips that each include a multiplexer in addition to the S/H amplifier and A/D converter. Siliconix's Si520 (5V supply, 14-kHz throughput) and Si8602 (15V supply, 40-kHz throughput) offer parallel outputs and include an 8-channel multiplexer, an S/H amplifier, and an 8-bit switched-capacitor A/D converter. TI's LinCMOS TLC1540 offers a serial data output and includes a 12-channel multiplexer (with one channel committed as a reference for self calibration), an S/H amplifier, and a 10-bit, switched-capacitor A/D converter. The TLC1540 can generate 62.5k samples/sec, and it comes in a 20-pin DIP or chip-carrier package. These converters, and the other new devices already mentioned, are more versatile than the earlier chip-level data-acquisition-system products (Analog Devices' AD7581 and National's ADC0808/0816, for example) because the internal S/H amplifier allows the chip to handle signals with much higher bandwidths.

At 12-bit resolution, ILC Data Device's hybrid ADC-00300 sampling converter offers 2-step subranging speed (2M samples/sec) with digital error correction and 3-state outputs. It comes in a 40-pin DIP, consumes 3.5W typ (4.5W max), and is spec'd for either the



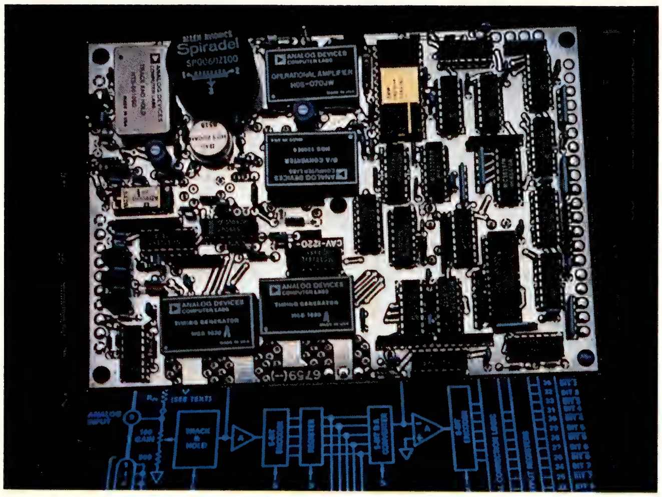
This monolithic, 12-bit, 5-μsec A/D converter, *the AD7572 from Analog Devices, is based on the linear-compatible CMOS process, BiMOS II.*

commercial or military temperature range. The HAS-1201 from Analog Devices has an architecture similar to that of the ADC-00300. It takes 1M samples/sec, comes in a 46-pin metal package, and consumes 3.0W typ (3.6W max).

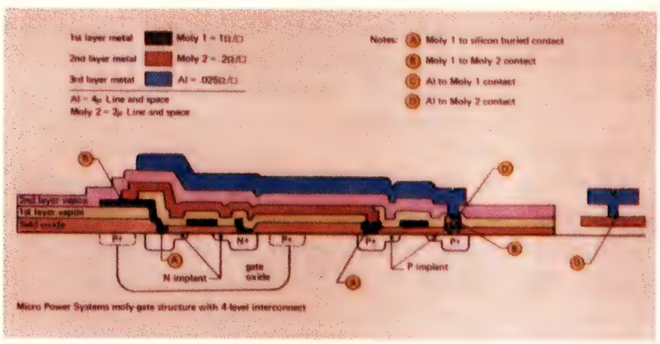
According to Micro Networks, its 12-bit sampling converters are the first to provide guaranteed dynamic performance based on digital-signal-processing techniques. The hybrid MN6227 (10V input span) and MN6228 (20V input span) are complete, successive-approximation types that take 33k samples/sec. In addition to the conventional dc specs, these converters specify the minimum output S/N ratio (70 dB) for any full-scale sine wave to 33 kHz, and the maximum amplitude for any output harmonic (−80 dB).

Sampling ADCs combine speed, resolution

At the far extreme of the sampling-converter continuum are high-resolution, high-speed parts. Two companies that supply such devices are Analog Solutions (formerly Zeltex) and Analogic. Both companies concentrate on the manufacture of modular data converters, which place discrete components on a small pc board that's encapsulated within a metal package. Although expensive, converters made this way are reparable and easily customized. Unlike IC converters, these parts show virtually no yield loss during manufacture. For an order of 50 units you need start a production run of just the 50 units; those that fail a performance test return to the line and are tweaked until they pass.



Containing hybrid and discrete ICs *on a 5×7-in. board, the 12-bit CAV-1220 sampling converter from Analog Devices converts at 20M samples/sec.*



A molybdenum-gate CMOS process *developed by Micro Power Systems provides four levels of interconnections: two patterns of molybdenum, one of aluminum, and one of silicon. The extra levels accommodate high-density circuitry for use in data converters.*

Analog Solutions' sampling converters include the 16-bit ZAD2836, the 16-bit ZAD2736, and the 15-bit ZAD2735. The first offers a 200k-sample/sec speed, and the other two offer low harmonic distortion at a 125k-sample/sec rate. In the low-distortion units' output spectrum, each harmonic component to 108 kHz is guaranteed to measure less than 0.005% of the fundamental. The ZAD2735 is pin compatible with Analogic's MP2735. All are based on the company's 3-pass, digitally corrected subranging architecture (see **box**, "Flash architectures: trading speed for complexity").

Analogic's Data Conversion Products Group offers the Adam Series of fast, high-resolution A/D converters. The sampling converters in this series include the 15-bit, 20k-sample/sec Adam-825A, the 16-bit, 435k-sample/sec Adam-826-1 (3.6W dissipation), and the 15-bit, 16.6k-sample/sec Adam-835A (only 0.9W dissipation). These converters also feature a 3-pass, subranging flash architecture with digital error correction. For time- or phase-related measurements on two or more channels, the Adam-822 is a 12-bit successive-approximation A/D converter with two S/H amplifiers that switch to the hold mode simultaneously. You can determine a transfer function with this device by making coincident measurements of an input and output signal, at a rate as high as 26k sample pairs per sec.

Flash conversion means high speed

Monolithic flash converters have come a long way since TRW introduced the first one, the 8-bit TDC1007, in 1977. Today, TRW offers full-flash converters with 4-, 6-, 7-, 8-, and 9-bit resolutions and with conversion rates as high as 100M samples/sec. All these parts are fabricated in the company's triple-diffused bipolar technology. All but the 7-bit TDC1147 have output latches. That device provides output data directly from its digital encoding section, and it's suitable for use in higher-resolution subranging converters.

Telmos has upgraded its TML1070 and TML1073 CMOS full-flash converters by replacing the open-drain data outputs with 3-state outputs. The new parts are the 7-bit, 10M-sample/sec TML1170 and the 7-bit, 7M-sample/sec TML1173.

Motorola has introduced an 8-bit parallel flash converter that first generates an internal Grey code to avoid large output glitches and then translates the Grey code to binary for presentation to the 3-state outputs. The bipolar MC10319 dissipates 618 mW and converts at 25M samples/sec. It provides an overrange bit that lets you operate two parts in series for 9-bit resolution, or two in parallel for 50M-sample/sec conversions.

Still more 8-bit bipolar-ECL flash converters are available from Sony, whose parts offer very high speeds and are intended primarily for digital video applications. The CX20116, for example, dissipates 1.2W while taking 100M samples/sec. Subranging types include the 8-bit, 20M-sample/sec, 700-mW CX20052A and the 10-bit, 20M-sample/sec, 350-mW CX20220-1.

Moly-gate CMOS suits flash-converter ICs

The broad selection of flash and subranging A/D converters shows that raw-speed applications represent a substantial volume of converter business. More significant, though, is the prospect that this converter type will capture an increasing share of applications served by the successive-approximation types; these

Besides saving space, sampling A/D converters remove the need to analyze many S/H-amplifier error contributions.

applications make up an enormous market. Products from Micro Power Systems could lead this incursion into the successive-approximation devices' territory.

Micro Power's molybdenum-gate CMOS process offers advantages that offset the resulting products' higher cost and complexity and particularly favor the fabrication of flash converters. First, you need high circuit density to accommodate all the comparators and encoding logic that a flash converter requires. Micro Power's chips achieve high density by using one or two layers of molybdenum in addition to aluminum to create as many as three layers of metal interconnect within the IC, and also because the small grain size of molybdenum aids in the fabrication of fine geometries.

Second, a low resistance in the reference ladder is essential for fast response in the presence of parasitic capacitance. Micro Power's 11-bit MP7685, for example, contains a reference string of 2048 resistors. By fabricating 0.8Ω resistors using molybdenum spec'd at 0.2Ω/square resistivity, the company keeps the resistor string's total resistance well under 2 kΩ. Third, monolithic construction and the low power dissipation of CMOS should give these products a reliability advantage over the more complex, hot-to-the-touch hybrid alternatives.

Two recent products from Micro Power are the already mentioned subranging MP7685 and the full-flash MP7584. The latter is an 8-bit, 20M-sample/sec device that operates from a 6V supply. It dissipates 300 mW typ. The MP7685 is an 11-bit, 2M-sample/sec part that operates from 5V and dissipates 100 mW max. A higher-resolution device is under development.

Flash architectures: trading speed for complexity

Although long recognized as the fastest method for analog/digital conversion, the parallel (flash) method was rarely used until the 1980s. Flash converters require one comparator per LSB, so a converter with 8-bit resolution, for example, requires 255 comparators. Even when VLSI techniques are used, 9-bit resolution is the current limit for this approach; IC designers turn pale at the thought of a 10-bit (1023 comparators) or 11-bit (2047 comparators) full-flash A/D converter.

Converter users are undaunted by these difficulties, though. They still want more speed and higher resolutions. The solution has been to modify the full-flash design in a way that trades speed for circuit complexity—ie, that results in monolithic devices with resolutions as high as 11 bits (12 bits is on the horizon) and with speeds faster than the equivalent successive-approximation converter types. Called half-flash, subranging, or multiple-pass A/D converters, these types require two or more passes (cycles) to complete a conversion. In contrast, the full-flash types convert in one clock cycle, and the successive-approximation types require n+1 cycles for n-bit resolution.

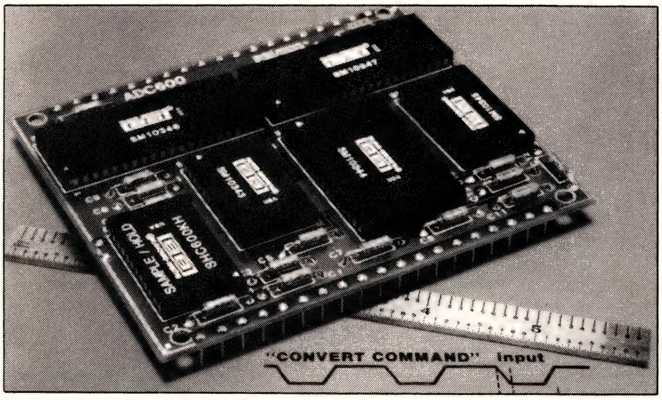
Two flash circuits

As an example, consider an 8-bit half-flash converter like the ADC0820 from National Semiconductor, or the AD7820 from Analog Devices. The input voltage goes to an internal 4-bit flash converter that determines the four MSBs. These four bits also go to a 4-bit D/A converter. Then a difference amplifier subtracts the DAC output from V_{IN} and feeds the result to a second 4-bit flash converter, which determines the four LSBs. Only 31 comparators are required in this design (15 in each 4-bit flash converter, plus one for over-range), and it completes a conversion in 1.36 or 1.52 μsec max.

As a variation, some subranging converters contain only one flash circuit instead of two, and they shuttle the one between two positions using analog switches. Also, higher-resolution subranging converters (like those from Analogic and Analog Solutions) require digital error correction to compensate for error in the MSBs.

Micropower Systems and Sony use another approach, one that eliminates the D/A converter and the analog subtractor circuit mentioned above. For an n-bit-resolution device, m "coarse" comparators select one $2^n/m$-resistor segment of the 2^n-resistor reference string; $2^n/m$ "fine" comparators then select one node within the segment. Again, the conversion takes two passes, and the required number of comparators is far smaller—$m+(2^n/m)$—than for an n-bit full-flash converter.

To build 50 modular data converters, you simply start with a production run of 50 units. Those that fail return to the line and are tweaked until they pass inspection.



Featuring six custom hybrids on a 4-layer pc board, *the ADC600 sampling converter from Burr-Brown provides 12-bit resolution, a 10M-sample/sec sampling rate, and 8.5W power dissipation.*

A discussion of high-speed A/D converters must not overlook LeCroy's Model 6880 waveform digitizer. This unit, a 2×8.7×11.5-in. module that's compatible with the CAMAC (IEEE-583) standard, is definitely not for panel meters. It generates 10,240 8-bit samples at a rate of 1.348G samples/sec, which makes it the fastest solid-state A/D converter you can buy. (The price is $15,500, plus $3950 for the associated control module.) During operation, the analog input is smeared, or demultiplexed, into 32 charge-coupled devices, each of which contains 320 analog storage cells. These 10,240 samples are then clocked into a conventional flash A/D converter at 2M samples/sec, and the results—representing a 7.6-μsec interval—are stored in memory.

A survey of recent D/A-converter offerings will help you understand how converter manufacturers can pack so much performance into their hybrid subranging and successive-approximation A/D converters—products that contain a D/A converter as one of many components. Monolithic 16-bit D/A converters, for example, have become reliable, mass-produced components in recent years. Although vendor's claims for "true" 16-bit performance should be investigated closely, you can find products that are monotonic to 16 bits over their operating temperature ranges.

Analog Devices, Harris, Micro Power Systems, and most notably Burr-Brown manufacture large quantities of monolithic 16-bit D/A converters. Other high-resolution monolithic D/A converters include Sony's dual, serial-input units for PCM audio applications, the CX20152 and CX20017; National Semiconductor's 16-bit LM1655 and Telefunken's 14-bit U 3014 M, optimized for accuracy in digital-potentiometer applications; and Intersil's 14-bit ICL7134 (also available from Datel as the DAC-7134). This last part contains linearity-correction circuits driven by data in a PROM, to provide 14-bit linearity without laser trimming.

Most 16-bit D/A converters do use laser trimming, however. Furthermore, because an extension of the R-2R ladder used in lower-resolution D/A converters requires that the MSB resistor be trimmed within 0.00076% for 16-bit accuracy, most manufacturers have chosen a segmented architecture that avoids such tight-tolerance trimming. In Micro Power's MP7616, for example, the four MSBs are decoded to provide control of 15 equal-valued current sources, each representing only 6.25% of the full-scale current. Compared with the straight R-2R approach, the trim tolerance on these current sources is relaxed by a factor of eight.

Digital feedthrough is another, serious problem for high-resolution D/A converters, yet it's generally unspecified on product data sheets. Feedthrough is unavoidable in a monolithic device; therefore, some vendors say that the input register and the converter should not be on the same chip. Hybrids achieve better performance by providing this separation, but the best system solution is simply to avoid digital activity at the converter inputs when the output accuracy is critical.

Internal DACs allow computer calibration

Analog Devices' AD569 is a monolithic 16-bit D/A converter that uses a voltage-segmented architecture to achieve 16-bit monotonicity over commercial, industrial, or military operating temperature ranges. What's more, the company's BiMOS II process provides the chip with a fast-settling output amplifier (5 μsec max to 0.001% for a full-scale step, with no load) and double-buffered input latches that allow multiple D/A converters to be loaded asynchronously and simultaneously updated.

The hybrid HS9371 from Hybrid Systems is also monotonic to 16 bits over the commercial and military temperature ranges, and it has double-buffered input latches that facilitate an interface to 8- or 16-bit buses. These latches are implemented in a semicustom gate array that reduces digital feedthrough, according to the manufacturer. Although, like the AD569, the HS9371 comes in a 28-pin DIP, the two products are not pin compatible.

Automatic test equipment and other systems that call for computer-driven adjustments of offset and gain are well served by Analog Devices' hybrid AD1148. This 16-bit D/A converter includes two additional 8-bit latched D/A converters, which replace the manual

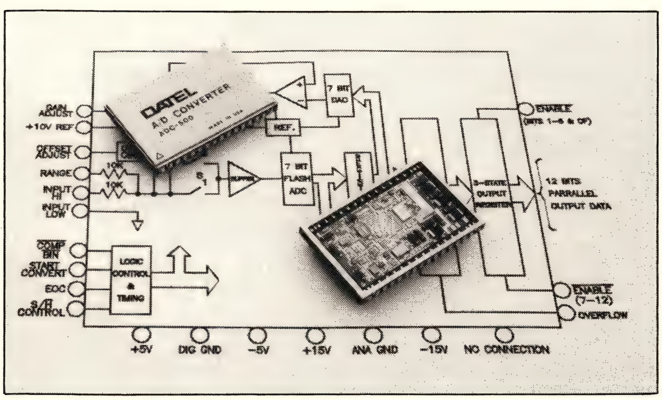
potentiometers normally used to adjust gain and offset. A separate 8-bit bus is provided for writing multiplexed data words to these adjustment DACs. Another model, the AD1147, multiplexes this data on the lower byte of the main D/A converter's 16-bit bus. Both models perform 4-quadrant multiplication and come in 32-pin DIPs.

Data-readback lets DACs remember

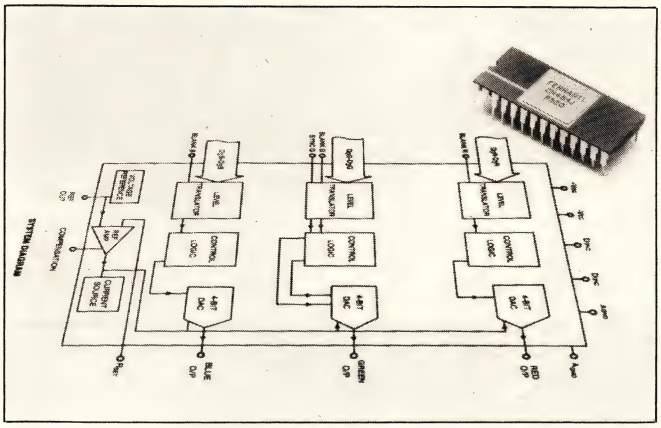
If you're looking for higher conversion speeds, you should consider the 14-bit hybrid DAC-02310 from ILC Data Device Corp. The device can make small-change updates at a rate of 10M samples/sec. The D/A-converter output includes a track/hold deglitcher that reduces the maximum glitch area to 750 mV-nsec. The device also includes an input register, a voltage reference, and timing circuits.

Lower-resolution parts like the quad 8-bit DAC-8408 from Precision Monolithics address the needs of systems that execute computer-controlled self-diagnostics and calibration. Converters in these systems operate in groups, so the inclusion of four in one package is a convenience. Furthermore, each D/A converter can read back, on command, the last digital word written to it. This convenience is for the computer, which no longer has to store these status words in system memory. The monolithic CMOS DAC-8408 comes in a 28-pin DIP. Also offering data readback is PMI's 12-bit CMOS DAC-8012. (PMI now offers at least 11 CMOS products in addition to its long-established line of precision bipolar products.)

Analog Devices also plans to provide readback capability in future D/A converters. Additional noteworthy D/A products from this company include the quad 8-bit



Providing a 500-nsec conversion time *with only 1.5W max power dissipation, Datel's 12-bit ADC-500 A/D converter uses a digitally corrected subranging architecture.*



A 100M-sample/sec, monolithic, triple-4-bit DAC, *the ZN454 from Ferranti is suitable for color-video graphics applications.*

AD7225 and the dual 12-bit AD7549, each a monolithic, linear-compatible CMOS chip. The AD7225 comes in a 28-pin DIP and has a common 8-bit data bus, but separate output amplifiers, double-buffered input latches, and reference inputs. The AD7549 comes in a 20-pin DIP and has a common 4-bit data bus for loading each converter in three consecutive 4-bit nibbles. Each 12-bit current-output D/A converter has a separate reference input and feedback resistor, and each performs 4-quadrant multiplication. Finally, the hybrid AD394 contains four 12-bit, voltage-output, 4-quadrant multiplying D/A converters, each independent of the others except for a common 12-bit data bus. The package is a 28-pin DIP.

Better DACs mean better ADCs

Improvements in D/A converters redound to the benefit of hybrid and modular A/D converters; most successive-approximation and subranging A/D converters use a D/A converter in their internal feedback loops. Two modular products—Burr-Brown's ADC600 and Analog Devices' CAV-1220—are conspicuous in the category of high-performance 12-bit A/D converters by virtue of the way they combine speed, resolution, power-dissipation, and size factors.

Burr-Brown has combined hybrid packaging technology with the disciplines of monolithic-IC and gate-array circuit development to produce the ADC600, a 10M-sample/sec converter that consists of six custom hybrids on a 3.75×4.5-in., 4-layer pc board. The converter includes no potentiometers; laser-trimming adjusts all critical accuracy and timing parameters at the hybrid-module level. Moreover, the converter is assembled from pretested hybrid modules chosen at random; it's

Digital feedthrough in high-resolution D/A converters is a serious problem, but it's rarely mentioned on product data sheets.

not necessary to select matched groups of modules. The performance is guaranteed at the 10M-sample/sec rate for input frequencies approaching the Nyquist limit. The typical power dissipation is 8.5W.

The 12-bit, 20M-sample/sec CAV-1220 from Analog Devices is based on a design proven by years of use. Built from monolithic and hybrid components on a 5×7-in. pc board, this converter contains an S/H amplifier and is ECL compatible. What's more, its 20M-sample/sec word rate doubles that of its predecessor, the 10M-sample/sec CAV-1210. The typical power consumption is 20.3W (22.3W max). Similarly, the 10-bit, 40M-sample/sec CAV-1040 sampling converter doubles the word rate of its predecessor, the 20M-sample/sec, pin-compatible MOD-1020. The CAV-1040 resides on a 5×7-in. board and consumes about 20W.

Datel's ADC-500 is another 12-bit hybrid A/D converter. It offers a 500-nsec conversion time with only

Manufacturers of data converters

For more information on data converters such as those discussed in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

Advanced Micro Devices
Box 3453
Sunnyvale, CA 94088
(408) 732-2400
Circle No 651

AEG Telefunken
Box 1109
7100 Heilbronn, West Germany
7131-8821
Circle No 652

Analog Devices Inc
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Norwood, MA 02062
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Circle No 653

Analog Solutions
940 Detroit Ave
Concord, CA 94518
(415) 686-6660
Circle No 654

Analogic Corp
Audubon Rd
Wakefield, MA 01880
(617) 246-0300
Circle No 655

Brooktree Corp
9950 Barnes Canyon Rd
San Diego, CA 92121
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Circle No 656

Burr-Brown Corp
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Tucson, AZ 85734
(602) 746-1111
Circle No 657

Data Translation
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Marlboro, MA 01752
(617) 481-3700
Circle No 658

Ferranti Electric
87 Modular Ave
Commack, NY 11725
(516) 543-0200
Circle No 659

GE Datel
11 Cabot Blvd
Mansfield, MA 02048
(617) 339-9341
Circle No 660

GE Intersil
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Cupertino, CA 95014
(408) 996-5000
Circle No 661

Harris Semiconductor Corp
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Melbourne, FL 32901
(305) 724-7000
Circle No 662

Honeywell Inc
Signal Processing Technologies
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Colorado Springs, CO 80906
(303) 577-1000
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Hybrid Systems Corp
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(617) 667-8700
Circle No 664

Hycomp
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Circle No 670

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Circle No 673

Micro Power Systems Inc
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Circle No 674

Mitsubishi Electronics Corp
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Motorola Inc
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(602) 244-6900
Circle No 676

National Semiconductor Corp
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Santa Clara, CA 95051
(408) 721-5000
Circle No 677

NEC Electronics
401 Ellis St
Mountain View, CA 94039
(415) 960-6000
Circle No 678

Phoenix Data Inc
3384 W Osborn Rd
Phoenix, AZ 85017
(602) 272-2331
Circle No 679

Plessey Semiconductor
3 Whatney
Irvine, CA 92714
(714) 951-5212
Circle No 680

Precision Monolithics Inc
1500 Space Park Dr
Santa Clara, CA 95050
(408) 727-9222
Circle No 681

Preston Scientific Inc
805 E Cerritos Ave
Anaheim, CA 92805
(714) 776-6400
Circle No 682

1.5W max power consumption. The device uses a single 7-bit flash converter in a 2-pass subranging configuration with digital error correction. It includes a 10V reference and 3-state outputs, but many applications will require an external S/H amplifier (such as Datel's SHM-4860). The converter comes in a 32-pin hermetically sealed package, and available versions guarantee performance over the commercial or military temperature ranges.

Raytheon Co
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Intech's IT 5245 continues the parade of 12-bit, 2-pass subranging A/D converters. This product converts at a 1M-sample/sec rate and is an alternate to the MN5245 from Micro Networks. Actually, Intech is an alternate source for a variety of hybrid products. Its A-8016 is an alternate for the 16-bit MP-8016 A/D converter from Analogic, the IT 574A is an alternate for the 12-bit, 20-μsec HI-574A from Harris, and the IT 674A is an alternate for the 12-bit, 12-μsec HI-674A from Harris. Rounding out the list of Intech's parts is the ADC 1140 A/D converter, a 16-bit hybrid that converts in 35 μsec. It operates from ±12 to ±17V supplies and dissipates 1.5W.

Emphasis for 12-bit ADCs is on speed

In addition to their more notable contributions to the 12-bit A/D category (that is, the CAV-1220 and the ADC600), Analog Devices and Burr-Brown each produce fast, 12-bit successive-approximation A/D converters with similar speed and power-dissipation specs. Burr-Brown's ADC803 converts in 1.5 μsec and dissipates 1.88W; the HAS-1202A from Analog Devices' Computer Labs Div converts in 1.56 μsec and dissipates 1.9W. Both hybrid converters come in 32-pin metal DIPs.

Maxim Integrated Products introduced the first alternate to Analog Devices' 12-bit AD578 hybrid A/D converter, and the first version of that product spec'd over the military temperature range (Maxim's AD578S, sporting a 4.5-μsec conversion time). Analog Devices, however, introduced its own 4.5-μsec, military-temperature version in February.

Almost as fast is Analog Devices' 12-bit, 5-μsec AD7572, which illustrates the capability of the BiMOS II process. This monolithic successive-approximation converter includes a buried zener reference, a comparator, and a 12-bit D/A converter in addition to the digital circuitry usually found in a CMOS converter chip. Housed in a 24-pin, 0.3-in. DIP and featuring 135-mW dissipation (215 mW max), the converter will also appear in future monolithic products, in combination with an S/H amplifier and with a multiplexer.

Harris Semiconductor has taken a different approach to 12-bit A/D-converter development. After introducing its 20-μsec version of the industry-standard 574-type (HI-574A), the company announced the faster 12-μsec HI-674A. More recently it introduced yet another faster version, the 7-μsec HI-774A. Each device contains a CMOS chip and a dielectrically isolated bipolar chip in a 28-pin DIP, and all parts are pin

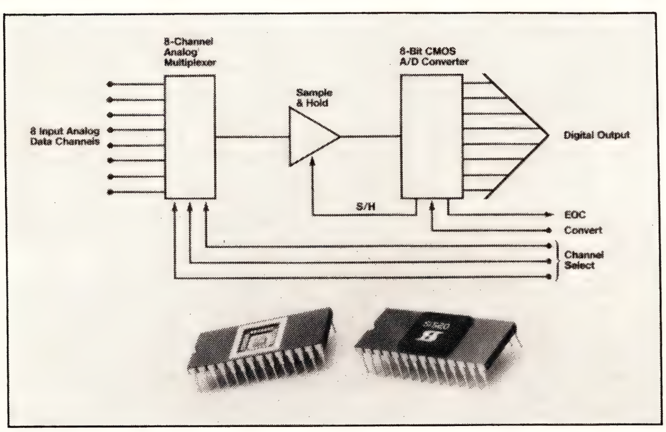
Flash converters may capture an increasing share of applications now served by the successive-approximation types—an enormous market.

compatible, of course. The HI-774A, however, employs a modified successive-approximation algorithm that provides digital error correction as well as enhanced speed. Because a correction occurs after the first eight MSBs are established, the analog input can vary by more than the customary ½ LSB during this period (actually, by ±31 LSBs). Consequently, the converter can maintain 12-bit accuracy while operating with a relatively slow S/H amplifier or other analog signal source.

Lower-resolution A/D converters include Precision Monolithics' first venture into the market. The company's monolithic-bipolar, 10-bit, 6-μsec ADC-910 is based on successive approximation and allows for a 2-byte interface to 8-bit data buses.

Moving on to resolutions beyond 12 bits, Intersil's ICL7115 A/D converter combines 14-bit resolution, a 40-μsec conversion time, and 60-mW max power consumption in a monolithic silicon-gate CMOS chip. Like its companion, the ICL7134 D/A converter, this A/D converter contains an onboard, factory-programmed EPROM for storage of linearity-correction data. This feature, plus an autozeroed comparator and separate force and sense lines for the analog input, ground, and reference, confer performance stability: The integral-linearity error TC is 1 ppm/°C typ (1.5 ppm/°C max), and the gain TC is 2 ppm/°C typ (5 ppm/°C max). Three-state outputs are organized as a 6- and an 8-bit byte. The package is a 40-pin DIP or leadless chip carrier.

Sixteen-bit A/D converters include the alternate-source successive-approximation types from Burr-Brown (ADC76) and Analog Devices (AD376). Both



This data-acquisition system on a chip, *Siliconix's CMOS Si520, includes an 8-channel multiplexer, a quasi-S/H amplifier, an 8-bit successive-approximation A/D converter, and a μP interface.*

hybrids come in 32-pin DIPs and convert to 14 bits in 15 μsec. Micro Network's hybrid MN5284 also comes in a 32-pin DIP, but with a different pinout. This 16-bit successive-approximation device converts in 50 μsec with only 300-mW max dissipation.

Also from Micro Networks is the MN5420 floating-point A/D converter. The part's 16-bit digital output is partitioned as a 12-bit mantissa and a 4-bit exponent, yielding a 20-bit dynamic range. This hybrid system contains, in a 40-pin DIP, a 4-bit geometric flash converter (the output changes at the power-of-2 values of the input voltage); a 9-range, autozeroed programmable-gain amplifier (for autoranging); two track/hold amplifiers and *sin* x/x antialiasing filters; and a 1-μsec subranging 12-bit A/D converter. During operation, the programmable gain amplifier automatically changes gain as required while the system maintains a 320k-sample/sec rate. Like the data sheet of the company's MN6227 described earlier, the MN5420 data sheet includes parameters based on a discrete Fourier analysis of the device's digital output data, in addition to the standard dc specs. This dynamic-performance information aids in evaluation of the converter for various DSP applications.

Integrating ADCs trade speed for accuracy

One class of A/D converters—the integrating type—traditionally trades speed for accuracy. Because they are relatively slow, most of these products are used in low-bandwidth applications such as digital panel meters, serial-output data acquisition, and weighing scales. One exception, though, is Sony's monolithic CX20018, developed for 2-channel digital-audio systems. Using a modified dual-slope circuit driven by an internal 28.1-MHz clock, this 16-bit device alternately samples the two channels and provides a 44.1k-sample/sec rate for each. The package is a 28-pin DIP.

Intersil's ICL7129 is a more conventional integrating A/D converter, but it is notable for high resolution; it directly drives a 4½-digit LCD. Available in a 40-pin plastic or ceramic package, the CMOS chip draws only 1 mW from a 9V supply. Maxim is an alternate source for this product (the ICL7129A) as it is for six other Intersil integrating A/D converters.

One special category of data converters comprises the D/A converters used to generate analog video signals. Comparable to the flash A/D converter in speed, most video DACs are application-specific products whose sync, blank, reference-white, and other control inputs allow the device to construct a standard

11-Bit Flash Converter

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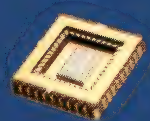

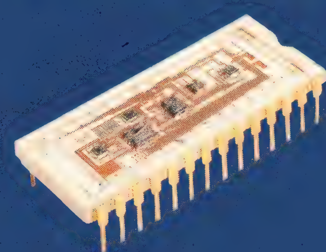

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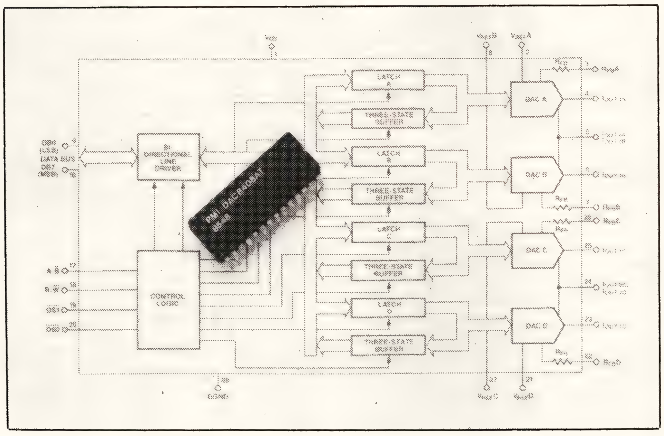
Most video D/A converters are application-specific products whose control inputs allow the device to construct a standard composite-video waveform.



A bidirectional 8-bit input register *provides readback capability for this 8-bit quad multiplying D/A converter, the monolithic CMOS DAC-8408 from Precision Monolithics.*

composite-video waveform. Because the converter's output may change value for each pixel in a raster-scan display, the input must accommodate a minimum 10M-sample/sec update rate for inexpensive 640×240-pixel displays, or a minimum 110M-sample/sec rate for high-resolution 1280×1024-pixel displays. (See **Ref 2** for a discussion of video D/A converters introduced before June 1985.)

ECL-compatible DACs provide highest speed

The higher-speed video D/A converters generally use ECL technology to achieve a comfortable margin of speed (the converter output should settle and dwell on each pixel for at least a few nanoseconds). A workstation used for solids modeling, for example, requires a fast D/A converter to support the CRT's high spatial resolution, but it also requires a D/A converter with a high resolution in bits (eight) to supply shading and fine detail in the display.

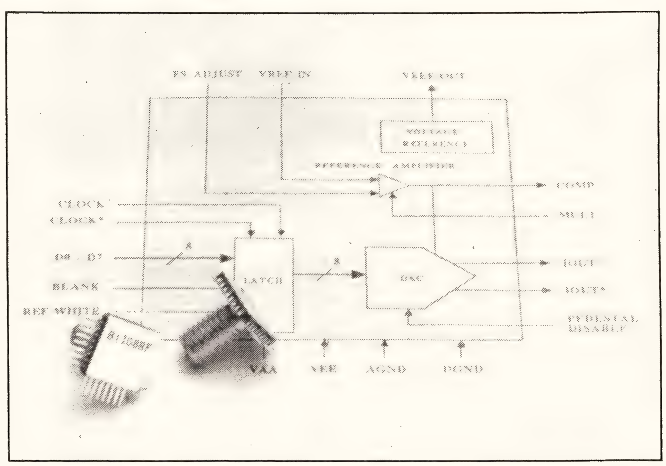
Brooktree's Bt108 meets these requirements. Compatible with either 100K- or 10K-ECL supply voltages (−4.5 or −5.2V), this 8-bit converter can operate at 200M samples/sec in the 24-pin-DIP version, or at 300M samples/sec in the 32-pin flatpack version. The recently introduced HDAC97000 from Honeywell also offers 8-bit, 200M-sample/sec operation. An alternate to Analog Devices' AD9700, this product comes in a 22-lead cerdip.

Other recent Honeywell introductions are the 275M-sample/sec HDAC10180 and HDAC10181. The first is a faster alternate to the older TRW TDC1018; the second is similar but contains a voltage reference. And at 400M samples/sec (385M guaranteed), the HDAC51400 is suitable for driving high-resolution 2k×2k-pixel displays. This level of operation exceeds the access time of ECL memories, so banks of memory must be configured to support this 8-bit D/A converter.

CMOS, of course, consumes less power than ECL, and current CMOS video D/A converters can deliver a respectable 125M-sample/sec update rate. Moreover, CMOS allows inclusion of a RAM color-look-up table on the D/A-converter chip. Manufacturers achieve further space savings by placing three D/A converters in one package, preferably with look-up tables as well. The result is a complete digital/analog interface for a color graphics display.

Brooktree's monolithic-CMOS Bt451, for example, includes a 256×12-bit RAM, a 4×12-bit overlay palette (for text, cursors, etc), and three 4-bit DACs, each capable of 125M-sample/sec operation. The on-chip memory holds 259 of the 4096 colors possible in a triple 4-bit system. Another video converter, the pin-compatible Bt458, is in the works. The part contains three 125M-sample/sec, 8-bit D/A converters; a 256×24-bit dual-port look-up RAM; and a 4×24-bit overlay palette on a CMOS chip. For those who can't wait for the Bt458, the Bt453 offers the same features except 40M-sample/sec operation and a 3×24-bit overlay palette.

Other Brooktree video D/A converters with RAM (known as "RAMDACs") are the 70M-sample/sec, triple-4-bit monolithic Bt450, which includes a 16×12-bit RAM and a 3×12-bit overlay, and the hybrid CMOS Bt452, which is similar to the Bt450 but has no overlay palette. Monolithic CMOS D/A converters without memory include the triple-8-bit, 50M-sample/sec Bt101



The 300M-sample/sec flatpack version *of Brooktree's 8-bit, ECL-compatible, Bt108 video D/A converter includes an integral heat sink.*

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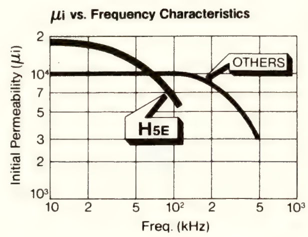

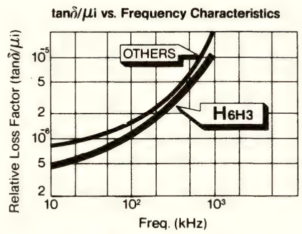

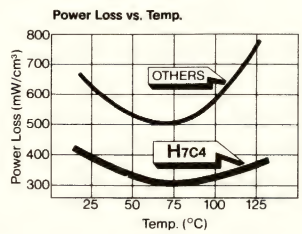

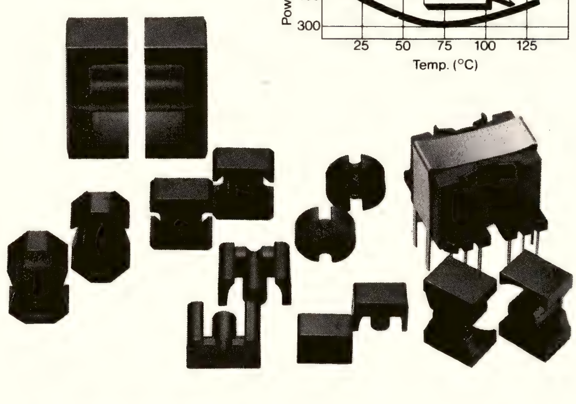

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and the single-8-bit, 50M-sample/sec Bt106. Finally, Brooktree offers the hybrid triple-4-bit, 40M-sample/sec Bt444, which is an alternate to Intech's VDAC444TD.

Using hybrid technology, Analog Devices has built a triple-8-bit video D/A converter with 256×8-bit look-up RAMs. The HDL-3805 offers latched composite-function inputs and a 115M-sample/sec update rate (the HDL-3806 is similar but lacks the latches). Also, Analog Devices has extended its HDG Series hybrid video DACs with the 4-bit HDG-0407 and the 8-bit HDG-0807, which offer 50M-sample/sec update rates and TTL-compatible inputs and operate from 5V supplies. The monolithic AD9702, on the other hand, is a triple-4-bit, 125M-sample/sec device that's compatible with either ECL or TTL.

Intech has added the monolithic, 8-bit binary, 40M-sample/sec, VDAC 1842 and the similar VDAC 1840 to its extensive line of video D/A converters. The latter accepts binary or complementary-binary inputs. Other video D/A converters worthy of mention are a variety of triple-4-bit types. From Intech, the 40M-sample/sec CMOS hybrid RGB DAC 4C includes a 16×12-bit RAM look-up table. Also from Intech, the monolithic bipolar RGB DAC 5150 furnishes a 16×12-bit look-up RAM and an 80M-sample/sec update rate. The RGB DAC 5151, without memory, converts 150M samples/sec. Analogic's 20M-sample/sec hybrid AH8304TM has a 32×12-bit RAM; the 100M-sample/sec AH8304TC has no memory. Ferranti's monolithic bipolar ZN454 is TTL compatible and sports a 100M-sample/sec update rate. TRW's monolithic bipolar TDC1334 is a 100M-sample/sec, ECL-compatible device.

Within two years, monolithic 8-bit video D/A converters will probably support the majority of graphics applications. And before the year's end, you can expect an 8-bit video D/A converter that integrates ECL-RAM look-up tables on chip. The tables will be organized as switched banks of memory to support high-speed operation. **EDN**

References

1. Travis, Bill, "Data converters," *EDN*, June 14, 1984, pg 118.
2. Travis, Bill, "Application-specific video D/A converters ease interface of CRTs to pixel memory," *EDN*, June 27, 1985, pg 59.

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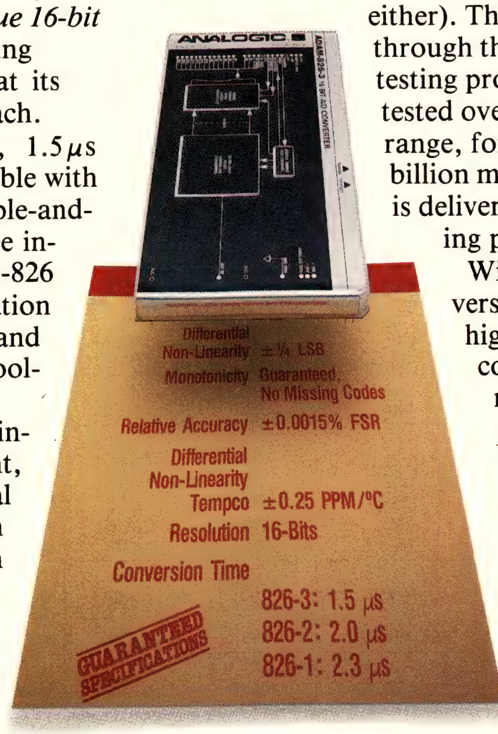

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INTERSIL					
ICL7115	14	(40)	(60)	$39	MONOLITHIC CMOS, EPROM ERROR CORRECTION
ICL7129CPL	4½ DIGITS	2 CONV/SEC	(18)	$13.13	MONOLITHIC CMOS, LCD DRIVE
LeCROY					
6680	8	1.3G	93.3W	$15,500 (1)	TRANSIENT DIGITIZER

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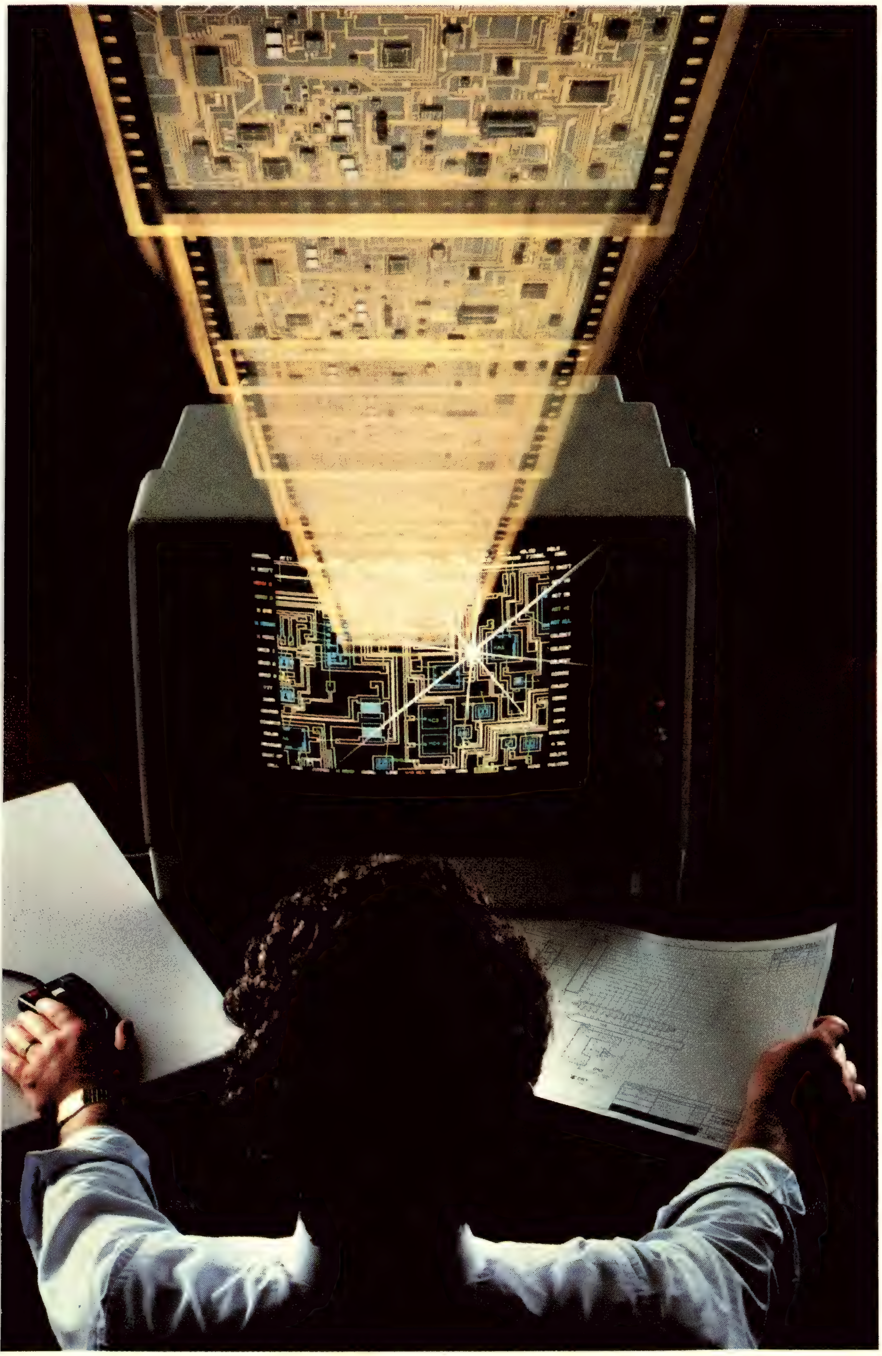
Table continued on pg 120

Custom Hybrid Solutions



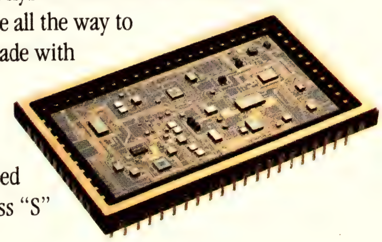
Our advanced engineering and manufacturing environment puts Hybrid Systems in great shape to meet your most sophisticated custom hybrid needs.

No one else in the industry has it. A manufacturing facility so advanced and sophisticated that it can transform your custom hybrid needs into custom hybrid solutions . . . more quickly, more economically, more expertly than ever before.

Our recent multi-million dollar investment in state-of-the-art automation equipment is a major factor in Hybrid Systems' emergence as a major force in custom hybrid design and production. Our CAE/CAD system helps us design your custom hybrids faster and better. Automated assembly equipment increases accuracy and reliability and decreases production time. And the most advanced LTX Automatic Test Equipment available ensures absolute dependability in even your most demanding applications.

It is precisely this investment—and our expert staff of Analog Signal Processing Engineers—that enables Hybrid Systems to create everything from single chip devices to a recent custom hybrid with 89 chips and over 760 wires.

Our custom hybrid solutions are available from industrial grade all the way to full military grade with MIL-STD-883 rev. C screening. They can also be produced to meet all Class "S" specifications.



This kind of performance exemplifies our ability to deliver efficient and reliable products that help your company get the edge on the competition.

Hybrid Systems: a proven center of Analog Signal Processing engineering expertise. And a proven center of advanced capabilities that's shaping the future in custom hybrid components.

For more information, contact us today at (617) 667-8700.

Hybrid Systems
CORPORATION
22 Linnell Circle, Billerica, MA 01821 617-667-8700

CIRCLE NO 72

REPRESENTATIVE ANALOG/DIGITAL CONVERTERS

MANUFACTURER AND MODEL	RESOLUTION (BITS)	UPDATE RATE*	POWER DISSIPATION (mW)**	PRICE (100)†	COMMENTS
MAXIM					
AD578S	12	(4.5)	(1075)	$198	MIL-TEMP
ICL7116CPL	3½ DIGITS	3 CONV/SEC	(16)	$5.95	MONOLITHIC CMOS, LCD DRIVE
ICL7117CPL	3½ DIGITS	3 CONV/SEC	(16)	$5.95	MONOLITHIC CMOS, LED DRIVE
ICL7129CPL	4½ DIGITS	2 CONV/SEC	(18)	$12.95	MONOLITHIC CMOS, LCD DRIVE
MICRO NETWORKS					
MN6227J	12	33k	(1095)	$74	HYBRID, S/H, 10V SPAN
MN6228J	12	33k	(1095)	$74	HYBRID, S/H, 20V SPAN
MN5284	16	(50)	255	$249	HYBRID
MN5420	16	320k	6700	$1295 (1)	HYBRID, S/H, 20-BIT (FLOATING-POINT) RANGE
MICRO POWER SYSTEMS					
MP7682JN	6	30M	150	$15.40	MONOLITHIC CMOS, PARALLEL
MP7683JN	8	5M	75	$44.30	MONOLITHIC CMOS, 2-STEP
MP7684JD	8	20M	350	$46.60	MONOLITHIC CMOS, PARALLEL
MP7685JD	11	2M	150	$142	MONOLITHIC CMOS, 2-STEP
MOTOROLA					
MC6108	8	(1.8)	(415)	$12.37	MONOLITHIC
MC10319	8	25M	(995)	$19.97 (1k)	MONOLITHIC, PARALLEL
NATIONAL SEMICONDUCTOR					
ADC0841CCN	8	(40)	(15)	$2.40	CMOS
ADC0844CCN	8	(40)	(15)	$3.20	CMOS, 4 CHANNELS
ADC0848CCN	8	(40)	(15)	$3.35	CMOS, 8 CHANNELS
ADC1005CCJ-1	10	(50)	15	$10.95	CMOS, 2-BYTE OUTPUT
ADC1025CCJ-1	10	(50)	15	$10.95	CMOS
ADC1205CCJ-1	13	(100)	(25)	$19.95	CMOS, 2-BYTE OUTPUT
ADC1225CCD-1	13	(100)	(25)	$19.95	CMOS
PRECISION MONOLITHICS					
ADC-910	10	(6)	400	$18.45	MONOLITHIC
SILICONIX					
Si520	8	14k EACH CHANNEL	(15)	$7.50	CMOS, 8 CHANNELS, S/H
Si7135	4½ DIGITS	5 CONV/SEC	(15)	$9 (1k)	CMOS
Si8601	8	(25)	2.5	$11.25	CMOS, 8 CHANNELS
SONY					
CX20052A	8	20M	700	$27	MONOLITHIC, SUBRANGING
CX20116	8	100M	1200	$640	MONOLITHIC, FLASH
CXA1066K	8	100M	1200	$640	MONOLITHIC, FLASH
CXA1056P	8	50M	550	$195	MONOLITHIC, FLASH
CXA1016P	8	30M	420	$90	MONOLITHIC, FLASH
CX20220-1	10	20M	350	$750	MONOLITHIC, SUBRANGING
CX20018	16	44k EACH CHANNEL	(725)	$21	MONOLITHIC, 2 CHANNELS
TELEDYNE PHILBRICK					
TP5210	12	(13)	(915)	$313	HYBRID
TELEFUNKEN					
U3009M	8	(160)	(5)	$4.50	MONOLITHIC NMOS, 4 CHANNELS, S/H
U6754B	4	110M	810	$45.75	MONOLITHIC, FLASH
TELMOS					
TML1170BI-C24	7	10M	150	$49.95	CMOS FLASH, 3-STATE OUTPUTS
TML1173BI-P20	7	7M	(150)	$31.25	CMOS FLASH, 3-STATE OUTPUTS
TEXAS INSTRUMENTS					
ADC0831A	8	(32)	(12.5)	$2.55	LinCMOS, SERIAL OUTPUT
ADC0832A	8	(32)	(26)	$2.93	LinCMOS, SERIAL OUTPUT, 2 CHANNELS
ACD0834A	8	(32)	(12.5)	$3.02	LinCMOS, SERIAL OUTPUT, 4 CHANNELS
ADC0838A	8	(32)	(12.5)	$3.16	LinCMOS, SERIAL OUTPUT, 8 CHANNELS
TLC1540I	10	62.5k EACH CHANNEL	(15)	$11.60	LinCMOS, SERIAL OUTPUT, 12 CHANNELS
TRW					
TDC1147	7	15M	(1009)	$23 (1k)	VIDEO, FLASH
TDC1044	4	25M	(385)	$13.40 (1k)	VIDEO, FLASH

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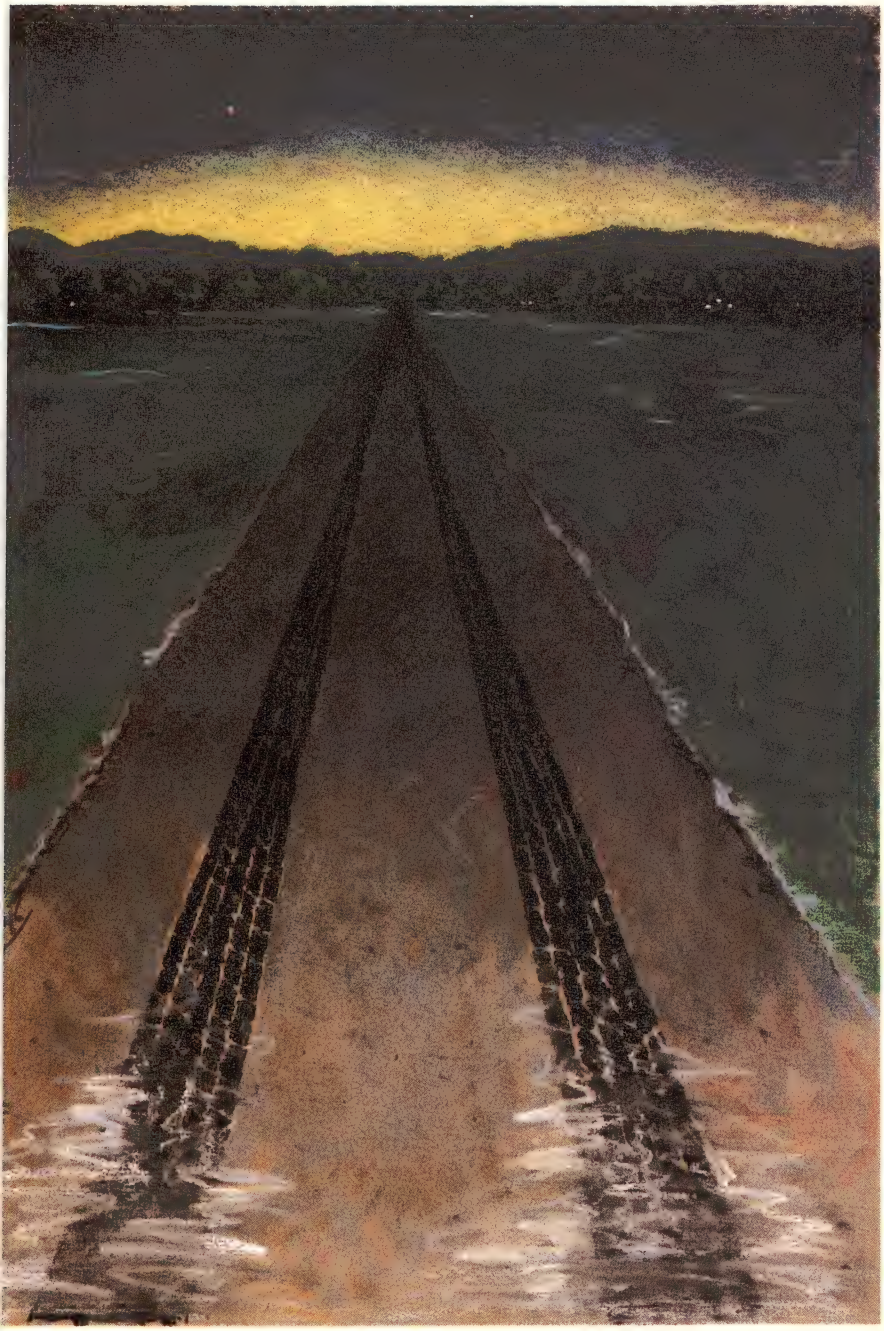
Hyspeed from Hybrid



Hybrid Systems' new CMOS Flash Converters and High Speed Hybrids provide an unbeatable combination of speed and uncompromising quality.

Now, Hybrid Systems brings its 20-year reputation for high quality, high reliability, and high performance to a new line of high speed products. Our monolithic flash converters and high speed hybrids are designed to meet the needs for fast digitizing and low power consumption in the most demanding real time data acquisition and analysis applications.

ANALOG TO DIGITAL

	RESOLUTION	CONVERSION TIME	POWER
HS9582*	6-bits	40 nsec	150mW
HS9583*	8-bits	200 nsec	75mW
HS9584*	8-bits	50 nsec	300mW
HS9520	12-bits	2.0 μsec	1.2W

DIGITAL TO ANALOG

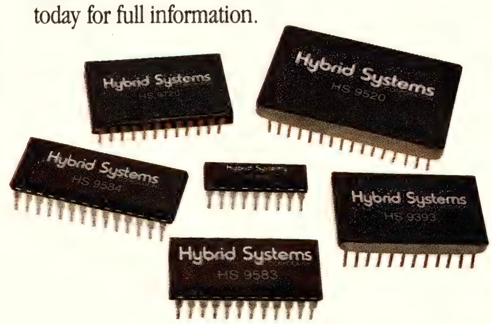
	RESOLUTION	SETTLING TIME	POWER
HS9393	12-bits	50 nsec	495mW

SAMPLE AND HOLD

	RESOLUTION	ACQUISITION TIME	POWER
HS9720	12-bits	200 nsec	765mW

*Flash Converters

All high speed components meet commercial and military temperature ranges. All products for military applications are processed to MIL-STD-883. Better still, all carry a name that is synonymous with expertise, reliability, and unsurpassed customer service: Hybrid Systems Corporation. Contact us today for full information.



Hybrid Systems
CORPORATION

22 Linnell Circle, Billerica, MA 01821 617-667-8700

CIRCLE NO 73

REPRESENTATIVE DIGITAL/ANALOG CONVERTERS

MANUFACTURER AND MODEL	RESOLUTION (BITS)	UPDATE RATE*	POWER DISSIPATION (mW)**	PRICE (100)†	COMMENTS
ANALOG DEVICES					
AD9702BW	4	125M	(1500)	$45	VIDEO, TRIPLE 4-BIT
AD9700BW	8	125M	(650)	$32	VIDEO
AD7224KN	8	200k	(60)	$4.95	BiMOS II, V_{OUT}
HDL3805BM	8	115M	(7550)	$181	TRIPLE HYBRID; 256×8-BIT LOOK-UP TABLES
HDL3806BM	8	115M	(7550)	$192	TRIPLE HYBRID, 256×8-BIT LOOK-UP TABLES, LATCHED CONTROL INPUTS
AD7225KN	8	200k	(165)	$18.50	BiMOS II, QUAD
HDG-0405BW	4	125M	(730)	$30	VIDEO, HYBRID
HDG-0605BW	6	125M	(730)	$38	VIDEO, HYBRID
HDG-0805BW	8	125M	(730)	$39	VIDEO, HYBRID
AD394JM	12	(15)	(750)	$115	QUAD HYBRID MDAC
AD667JN	12	(2)	(300)	$9.90	DOUBLE-BUFFERED
AD7536JN	14	(1.5)	(100)	$18.95	BiMOS II
AD7535JN	14	(1.5)	(60)	$18.95	BiMOS II
AD7534JN	14	(1.5)	(36)	$16.95	BiMOS II
ADDAC71H	16	(10)	(850)	$42	HYBRID
ADDAC72C	16	(10)	(850)	$49.50	HYBRID
HDG-0407BW	4	50M	(1125)	$35	VIDEO, HYBRID
HDG-0807BW	8	50M	(1125)	$43	VIDEO, HYBRID
AD7549JN	12	(1.5)	(75)	$16.95	BiMOS II, DUAL
AD569JN	16	(3)	(200)	$19	BiMOS II
AD1147	16	(18)	(450)	$152	HYBRID
ANALOGIC					
AH8308EC	8	150M	(2500)	$86	TRIPLE, HYBRID, VIDEO
AH8304EC	4	150M	(1250)	$49	TRIPLE, HYBRID, VIDEO
AH8404TC	4	25M	(600)	$52	TRIPLE, HYBRID, VIDEO
BROOKTREE					
Bt101BC	8	50M	(875)	$75	TRIPLE, VIDEO, CMOS
Bt106BC	8	50M	(500)	$27	VIDEO, CMOS
Bt108BF-300	8	300M	(1000)	$87	VIDEO, BIPOLAR
Bt444KC	4	40M	600	$79	VIDEO, TRIPLE, BIPOLAR
Bt450KC-70	4	70M	750	$43	VIDEO, TRIPLE, MONOLITHIC CMOS; LOOK-UP TABLES
Bt451KG	4	125M	(1600)	$175	VIDEO, TRIPLE, MONOLITHIC CMOS; LOOK-UP TABLES
Bt452KC	4	40M	1200	$85	VIDEO, TRIPLE, HYBRID; LOOK-UP TABLES
Bt453KC	8	40M	750	$58	VIDEO, TRIPLE, MONOLITHIC CMOS; LOOK-UP TABLES
BURR-BROWN					
DAC1200KP-V	12	(7, TYP)	(605)	$5.95	
DAC1201KP	12	(7, TYP)	(705)	$6.95	
PCM53JP-I	16	(3, TYP)	(950)	$17	AUDIO, MONOLITHIC
PCM54HP	16	(3, TYP, V_O)	(540)	$10.90	AUDIO, MONOLITHIC
DAC71-COB-I	16	(1)	625	$37	MONOLITHIC
DAC72BH-CSB-V	16	(10)	(950)	$53	MONOLITHIC
DAC1600JP-V	16	(10)	1090	$8.95	MONOLITHIC
DATEL					
DAC-7134B	14	(3)	(500)	$32.95	MONOLITHIC MDAC; PROM ERROR CORRECTION
FERRANTI					
ZN429D	8	(1, TYP, V_O)		$1.25 (5k)	SO-14 PACKAGE
ZN454	4	100M		$30	VIDEO, TRIPLE
ZN558E	8	(0.8, TYP, V_O)	75	$3.62	
HARRIS					
HI-5690V-5	12	(1.2)	585	$24.55	MONOLITHIC; DAC80-COMPATIBLE
HONEYWELL					
HDAC97000	8	200M	728	$23 (1k)	VIDEO, MONOLITHIC
HDAC34010	4	200M	1794	$39 (1k)	VIDEO, MONOLITHIC, TRIPLE, ECL-COMPATIBLE
HDAC34020	4	100M	1924	$39 (1k)	VIDEO, MONOLITHIC, TRIPLE, TTL-COMPATIBLE
HDAC10181	8	275M	680	$43.75	VIDEO; INCLUDES V_{REF}
HDAC51400	8	385M	800	$42.50	VIDEO
HYBRID SYSTEMS					
HS9371K	16	(5, TYP)	(45)	$65	HYBRID MDAC
HS9378C	16	(22, TYP)	(550)	$75	HYBRID

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Table continued on pg 124

On November 13, 1985, Thomson acquired most of Mostek's assets. It's good news for Thomson. It's good news for Mostek.

And it's good news for you.

Now with the newly formed THOMSON COMPONENTS-MOSTEK CORPORATION, we are reinforcing both our product-based technologies and our worldwide marketing network.

But when you get right down to it, products and technologies are not enough. A company's most valuable assets are the trust and respect of its customers.

And we are going on record as saying that THOMSON COMPONENTS is committed to earning your trust and respect. Not to mention your business.

For a company our size, we now have a larger base of diversified products than anyone in the industry. And our U.S. operation includes design, world-class photomask and fabrication, assembly and test all at one site. Which enables us to react instantly to your changing business needs.

What's more, we're working hard at matching our products to your application requirements and improving the service and support that goes with them.

In coming weeks, you'll be learning more about both our products and company. But in the meantime, we just wanted to let you know how much we appreciate your support. And how much we value your business.

Jacques Noels
Chairman

Jim Fiebiger
President and CEO

THOMSON
COMPONENTS
MOSTEK

1310 Electronics Drive, Carrollton, Texas 75006, MS 2205, 214-466-6000

CIRCLE NO 74

REPRESENTATIVE DIGITAL/ANALOG CONVERTERS

MANUFACTURER AND MODEL	RESOLUTION (BITS)	UPDATE RATE*	POWER DISSIPATION (mW)**	PRICE (100)†	COMMENTS
ILC DATA DEVICE					
DAC-02310	14	(1.8, TYP)	(1775)	$269	DEGLITCHED, MIL-TEMP
INTECH					
VDAC1840	8	40M	(225)	$24	VIDEO, 24-PIN DIP
VDAC1842	8	40M	(225)	$20	VIDEO, 20-PIN DIP
RGBDAC4C	4	40M	(1500)	$94	VIDEO, TRIPLE, HYBRID
RGBDAC5150	4	80M	(1175)	$52	VIDEO, TRIPLE, MONOLITHIC, LOOK-UP TABLES
RGBDAC5151	4	150M	(1000)	$45	VIDEO, TRIPLE, MONOLITHIC
INTERSIL					
ICL7134J	14	(3)	(2.5)	$14.25	MONOLITHIC CMOS, EPROM ERROR CORRECTION
MICRO POWER SYSTEMS					
MP7614JN	14	(2, TYP)	(64)	$13.85	CMOS MDAC
MP7616JN	14	(2, TYP)	(64)	$15.40	CMOS MDAC
MP7545JN	12	(1, TYP)	20	$7.85	CMOS BUFFERED MDAC
MP7628JN	8	(0.5, TYP)	25	$8.92	CMOS BUFFERED QUAD MDAC
MP7633JN	10	(0.5, TYP)	20	$3.80	CMOS MDAC
PRECISION MONOLITHICS					
PM-7524HP	8	(0.3)	(5)	$4.05	CMOS BUFFERED MDAC
PM-7528HP	8	(0.35)	(5)	$5.35	CMOS BUFFERED MDAC, DUAL
PM-7533HP	10	(0.6)	(30)	$4	CMOS MDAC
PM-7541HP	12	(1.0)	(30)	$7.16	CMOS MDAC
PM-7545HP	12	(1.0)	(30)	$7.20	CMOS BUFFERED MDAC, 5 TO 15V
PM-7645HP	12	(1.0)	(30)	$7.20	CMOS BUFFERED MDAC, 15V ONLY
DAC-8012HP	12	(1.0)	(30)	$8.28	CMOS BUFFERED MDAC WITH READBACK
DAC-8212HP	12	(1.0)	(30)	$15.26	CMOS BUFFERED MDAC, DUAL
DAC-8408HP	8	(0.25)	(5)	$8.03	CMOS BUFFERED DUAL MDAC WITH READBACK
RAYTHEON					
DAC-4888DD	8	(2.5)	(450)	$7.14	LATCHES, V_{OUT}, V_{REF}
SILICONIX					
Si8020CJ	12	(2)	(40)	$14.85	CMOS DOUBLE-BUFFERED MDAC
SONY					
CX20017	16	(10)	473	$10	AUDIO, DUAL
CX20152	16	(5)	600	$10	AUDIO, DUAL
CX20201	10	100M	430	$77	VIDEO
CX20202	10	100M	430	$77	VIDEO
CX20051A	10	30M	550	$20	VIDEO
TELEDYNE PHILBRICK					
4065	12	(0.06)	(645)	$199	I_{OUT}, V_{REF}
4080	12	(0.25)	(900)	$317	V_{OUT}, V_{REF}
TELEFUNKEN					
U 3014 M	14	(10)	—	$10	MONOLITHIC NMOS, POTENTIOMETER TYPE
U 3310 M	10	(50)	180	$10	MONOLITHIC NMOS, TRIPLE, POTENTIOMETER TYPE
U 3418 M	8	(50)	120	$10	MONOLITHIC NMOS, QUAD, POTENTIOMETER TYPE
TELMOS					
TML1840BI	8	25M	85	$32.65	VIDEO, CMOS
TML1842EI	8	40M	85	$11.55	VIDEO, CMOS
TML1850BI	8	85M	(150)	$27.50	VIDEO, CMOS
TML1852EI	8	85M	(150)	$7.95	VIDEO, CMOS
TML1863-B1-P28	6	55M	140	$24.95	VIDEO, CMOS, TRIPLE
TRW					
TDC1012	12	20M	(1100)	$58 (1k)	VIDEO, LOW GLITCH
TDC1034	4	125M	(754)	$15 (1k)	VIDEO
TDC1318	8	125M	(1800)	$39 (1k)	VIDEO, TRIPLE
TDC1334	4	125M	(1500)	$29 (1k)	VIDEO, TRIPLE

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IF YOU COULD HAVE THE IDEAL LOGIC DEVICE, WHAT WOULD IT BE?

OF CO
A PROGRAMMA

You've known it all along.

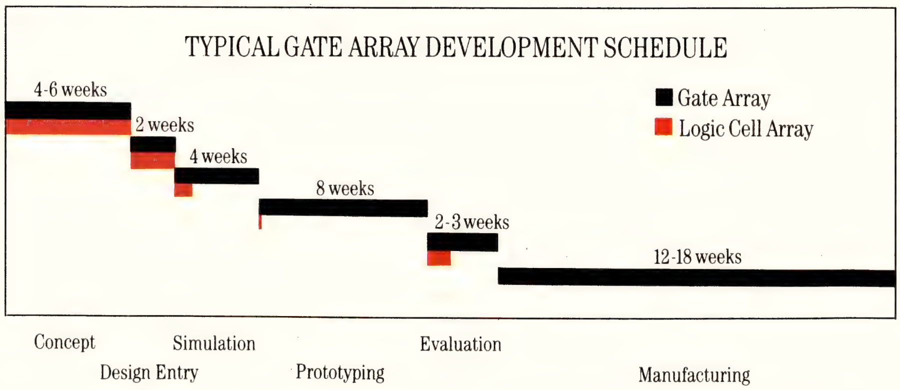
Now, the ideal logic device is finally here: Real gate array density. Real gate array architecture. Real gate array flexibility. And fully user programmable.

It's called the Logic Cell™ Array and it's from Xilinx.

A GATE ARRAY. ONLY BETTER.

The Logic Cell Array offers all the advantages—but none of the disadvantages—of conventional gate arrays. Unlike them, the Logic Cell Array isn't manufactured. Merely programmed. And it can be reprogrammed an unlimited number of times. Even while it's in the system.

That means turnaround time on design revs can be measured in hours, not months. Time-to-market can be reduced accordingly. And non-recurring engineering charges are non-existent.



Since you program it yourself, the Logic Cell Array shortens design verification and prototyping to almost nothing, and completely eliminates manufacturing. That cuts about 5½ months out of the typical schedule. And that's just on the first go-round. If you have to change the Logic Cell Array, all you do is reprogram it. That could take you a whole afternoon.

Logic Cell Arrays are also standard parts. So we can test every one of them 100%, down to the last transistor, before you ever get them.

It also means that, unlike gate arrays, you can get Logic Cell Arrays off-the-shelf, through distribution.

The specs on this little silicon gem?

Part No. XC-2064. CMOS. 40 MHz. And 1200 honest, usable gates. Look for 3000 gates by year-end.

LOGIC THAT WORKS LIKE A MICROPROCESSOR.

The problem with logic devices, gate arrays in particular, is they're hard-wired. So your design is literally cast in silicon.

It might as well be cast in cement.

Imagine, though, how much simpler your life would be if your logic device had the flexibility of

With the Logic Cell Array's real time in-ciruit emulation, you get 100% design verification, in the system. It's the real thing. The best you can do with a gate array is simulation. Which is about as close to the real thing as a decoy is to a real duck. So how can you really be sure your design is going to fly?

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URSE.
BLE GATE ARRAY.

a microprocessor. Well, the Logic Cell Array has that flexibility. Because it works very much like a microprocessor.

At power up, the Logic Cell Array automatically loads its internal CMOS static memory. This memory defines the logic functions and interconnections within the Logic Cell Array to build your logic circuit.

As for the advantages of such an approach, just go ask the microprocessor guys.

As for the advantages of being based on CMOS memory, talk to those who work with memory about how much they like parts that continually drop in price while increasing in density and performance.

Because the Logic Cell Array is going to do that, too.

A FULL ARRAY OF DEVELOPMENT SYSTEM SUPPORT.

You don't have to be an expert in semiconductor manufacturing to use the Logic Cell Array. You just have to know logic design.

And you don't have to be a programming expert to use any part of our integrated development system, either.

There's an interactive, graphics-based, mouse-and-menu-driven configuration editor that you can learn in an afternoon.

A simulator. An in-circuit emulator that runs real I/O and real software in real time for complete and positive design verification.

Plus documentation at the touch of a button and host of other why-didn't-somebody-think-of-that-before facilities.

Best of all, it runs on an IBM® PC XT,™ AT™ or clone. And you can get started for the modest price of just $3600.

Instead of a lot of gate arrays that each do one thing, the Logic Cell Array is one gate array that can do everything. Including cut your inventory risk to zero, let you make field upgrades, and eliminate NRE.

TRY IT. $250.

We've arranged a way for you to find out firsthand what you can do with the Logic Cell Array. It's our Evaluation Kit (otherwise known as EK-01). And it's just $250.

It includes enough software and documentation to evaluate your application on a Logic Cell Array, and see if it performs up to snuff. If you decide the Logic Cell Array is just what you need, we'll credit your $250 towards the purchase of our XACT™ development system.

To order, call Hamilton/Avnet toll-free at 1-800-4-HAMILTON. Or contact your local Xilinx sales office or Xilinx representative.

Immediately, if not sooner.

Now that the ideal logic device is here, isn't this the ideal time to use it?

XILINX
The Programmable Gate Array Company.

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CIRCLE NO 75

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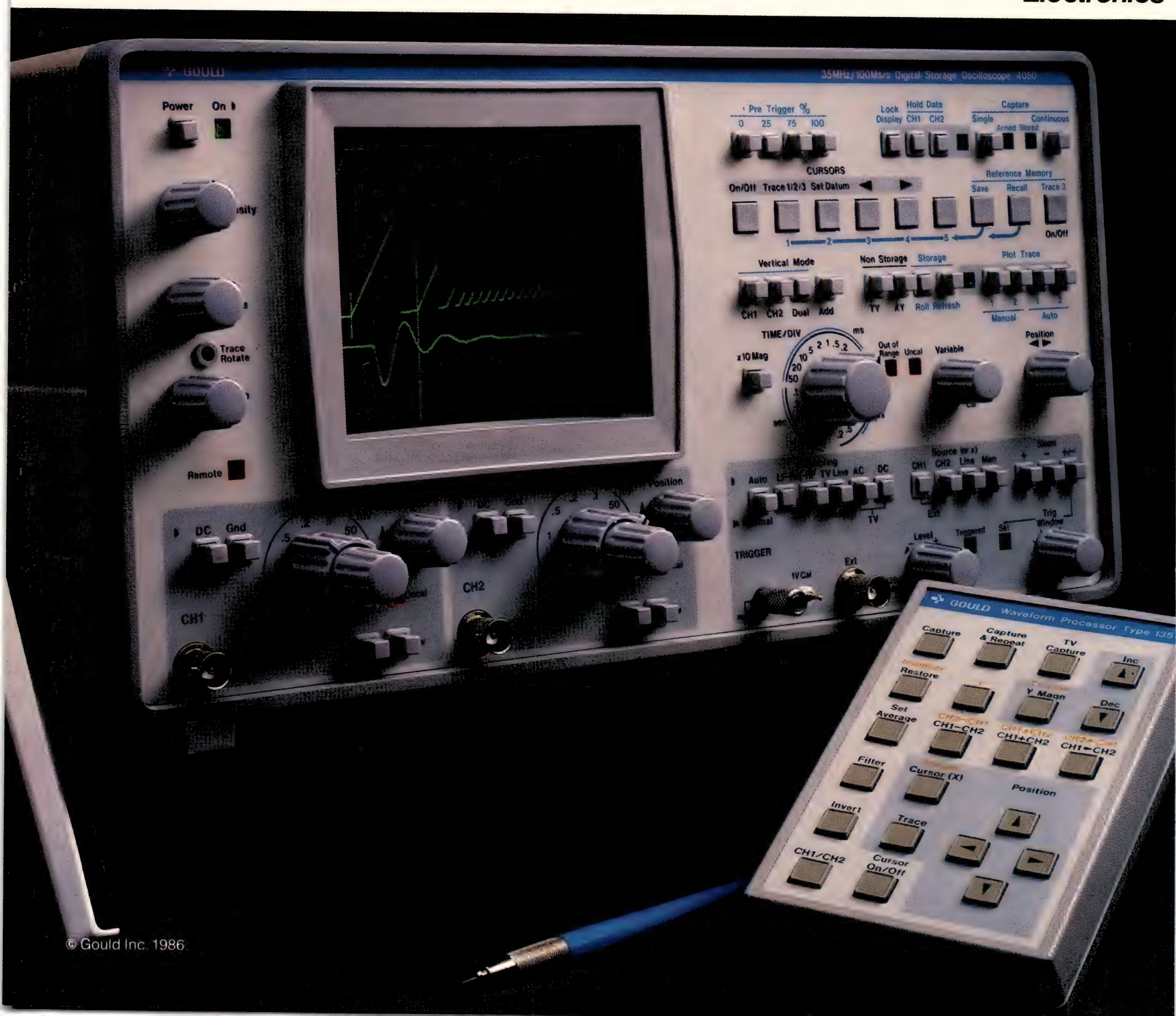

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Designer's Guide to:
Op-amp booster stages—Part 1

Boost op-amp output without sacrificing drift and gain specs

Many applications require greater output power than most monolithic op amps can deliver. When you need augmented voltage or current gain (or both) from low-power amplifiers, you must add separate output stages, such as the ones described in this, the first article of a 2-part series. However, an output stage's added gain and phase shift can cause poor ac response or outright oscillation unless you judiciously apply the frequency-compensation methods that part 2 will discuss.

Jim Williams, *Linear Technology Corp*

Standard IC processing techniques limit the total power-supply span for most monolithic op amps to 36 volts, thus limiting available output swing. In addition, supplying current beyond tens of milliamperes requires large output transistors, which dissipate more power than most IC op amps can handle. To attain greater outputs from these limited-voltage and -current amplifiers, you must add a power-gain stage.

This booster stage usually sits within the monolithic amplifier's feedback loop, preserving the IC's low drift and stable gain characteristics. But when an output stage resides in the amplifier's feedback path, you must be concerned with the feedback loop's stability; part 2 of this series (scheduled for June 12) will discuss frequency-compensation considerations.

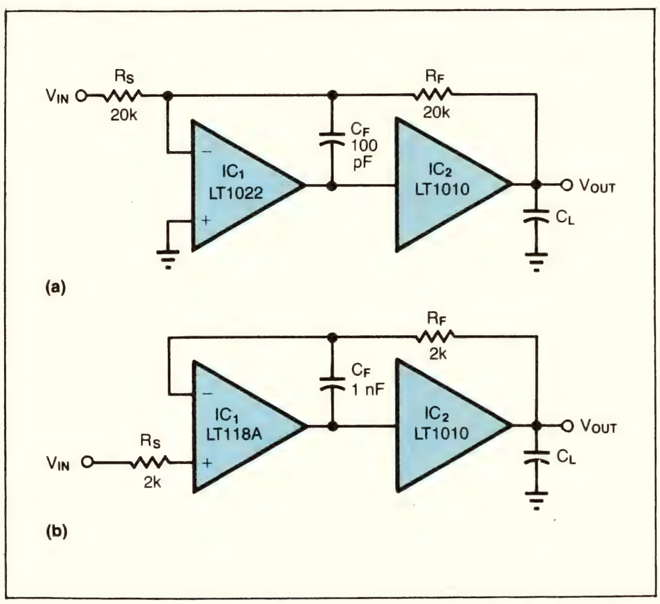


***Fig 1—The interstage capacitor, C_F,** shorts out the feedback loop at high frequencies so that phase shift from the load's capacitance won't cause loop instability.*

The circuitry needed in an output stage varies with the application. Current and voltage boosting are common requirements, and both are often simultaneously required. Voltage-gain stages usually mandate high-voltage power supplies, but output stages that generate their own high voltages are an alternative.

Fig 1a shows the LT1010 monolithic 150-mA current

Usually, the booster stage is within the monolithic amplifier's feedback loop, preserving the IC's low drift and stable gain characteristics.

booster residing within the feedback loop of a fast FET amplifier. At low frequencies, the buffer's offset-voltage and gain errors are negligible. At higher frequencies, C_F shorts out the feedback loop so that phase shift from the load capacitance acting with the buffer's output resistance doesn't cause loop instability. At high frequencies, the buffer amp is, in effect, out of the op amp's feedback loop. The LT1010 is particularly adept at driving large capacitive loads such as cables.

C_F reduces small-signal bandwidth, but you can obtain considerable load isolation without reducing bandwidth below the power bandwidth. (It's common to require a bandwidth reduction to filter high-frequency noise or unwanted signals, in any case.) The follower configuration **(Fig 1b)** is unique in that the circuit achieves capacitive-load isolation without a reduction in small-signal bandwidth, though the output impedance of the buffer comes into play at high frequencies. This precision unity-gain buffer has a 10-MHz bandwidth without capacitive loading, yet it's stable for load capacitance as high as 0.3 μF.

Both circuits in **Fig 1** will deliver 150 mA of output current. The LT1010 supplies short-circuit and thermal-overload protection. The op amp you select sets the slew limit.

Fig 2 uses a discrete stage to provide a 3A-output capability. The configuration shown provides a clean, quick way to increase the LT1010's output power. The circuit proves useful for high-current loads, such as linear-actuator coils in disk drives.

The grounded 100Ω resistor supplies a load for the LT1010 while the 33Ω resistors sense the LT1010's supply current. The voltage drop across the 33Ω resistors biases Q_1 and Q_2. The other 100Ω resistor closes a local feedback loop, stabilizing the output stage. Feedback to the LT1056 control amplifier is via the 10-kΩ resistor. Q_3 and Q_4, sensing across the 0.18Ω resistors, furnish current limiting.

The output transistors have low f_T and need no special frequency compensation. The 68-pF capacitor

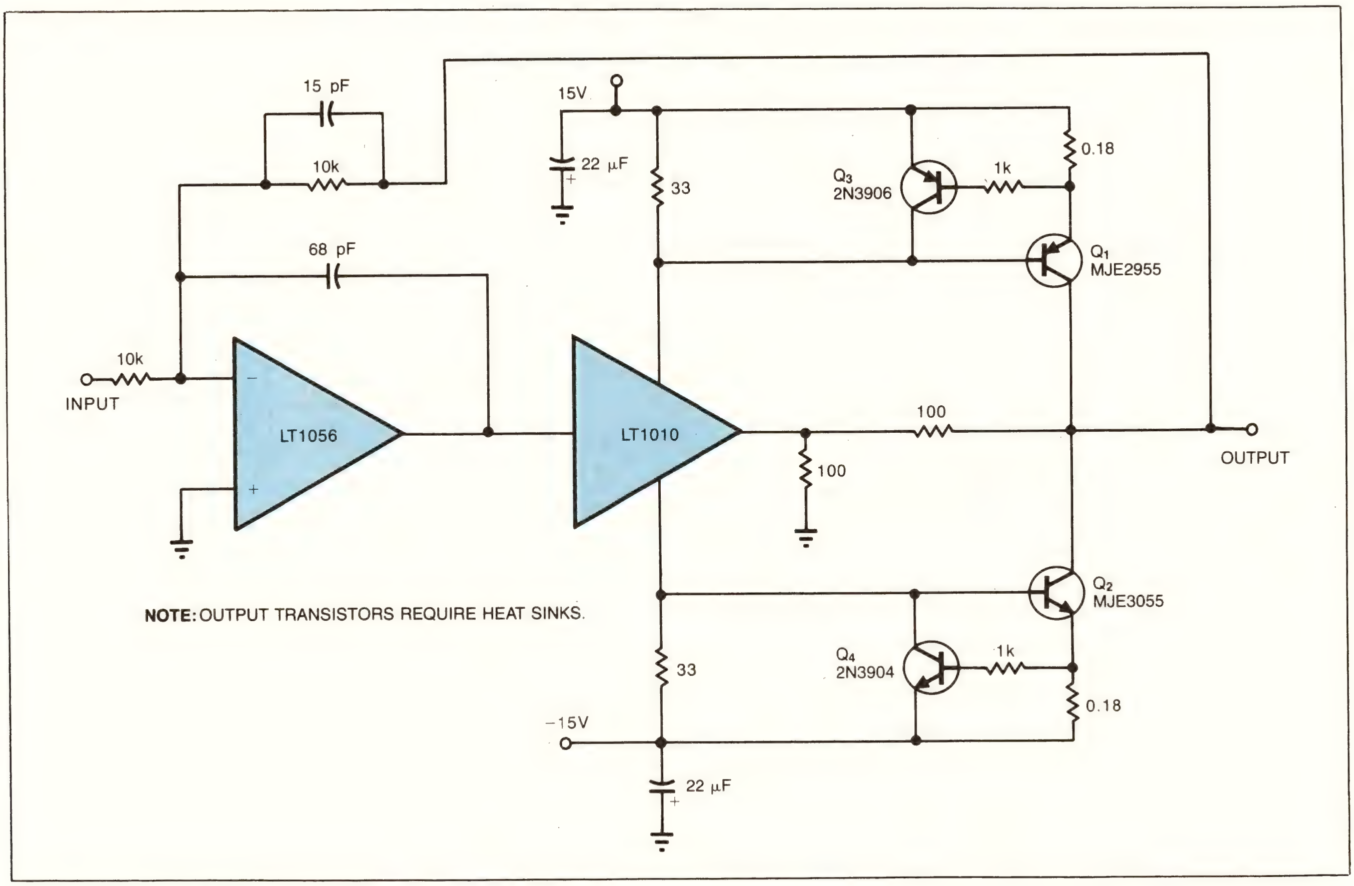


***Fig 2—This circuit provides a clean, quick** way to increase the op amp's output power to 3A.*

rolls off the frequency response of the LT1056 for dynamic stability, and the 15-pF feedback capacitor trims edge response. At full power (±10V, 3A pk), bandwidth is 100 kHz and slew rate is about 10V/μsec. Harmonic distortion measures below 1% at 1 kHz.

The circuit in **Fig 3** features higher power and has lower harmonic distortion—about 0.05%. This discrete stage provides a 5A-output capacity. Current sources Q_1 and Q_2 bias the complementary Darlington output transistors, Q_3 and Q_4. The dashed lines indicate that Q_3 and Q_4 must be in physical contact with the 1N914 diodes for thermal mating, allows the transistors' biasing to track over temperature, avoiding thermal runaway in the output stage. Note also that Q_3 and Q_4 require heat sinks. Q_5 and Q_6 limit current by diverting drive from the output-stage transistors' bases. The transistors' V_{BE} turn-on voltage (about 0.6V) across the 0.1Ω shunts sets a 6A current limit.

Diodes provide temperature compensation

The Darlington transistors have low f_T, and the stage exhibits low frequency response. The 39-pF capacitor rolls off the LT1055's frequency response locally for dynamic stability. This compensation permits overall response approaching that of the op amp alone. At full power (±10V, 5A pk), bandwidth is 100 kHz and slew rate is about 10V/μsec.

All the circuits discussed so far place the output

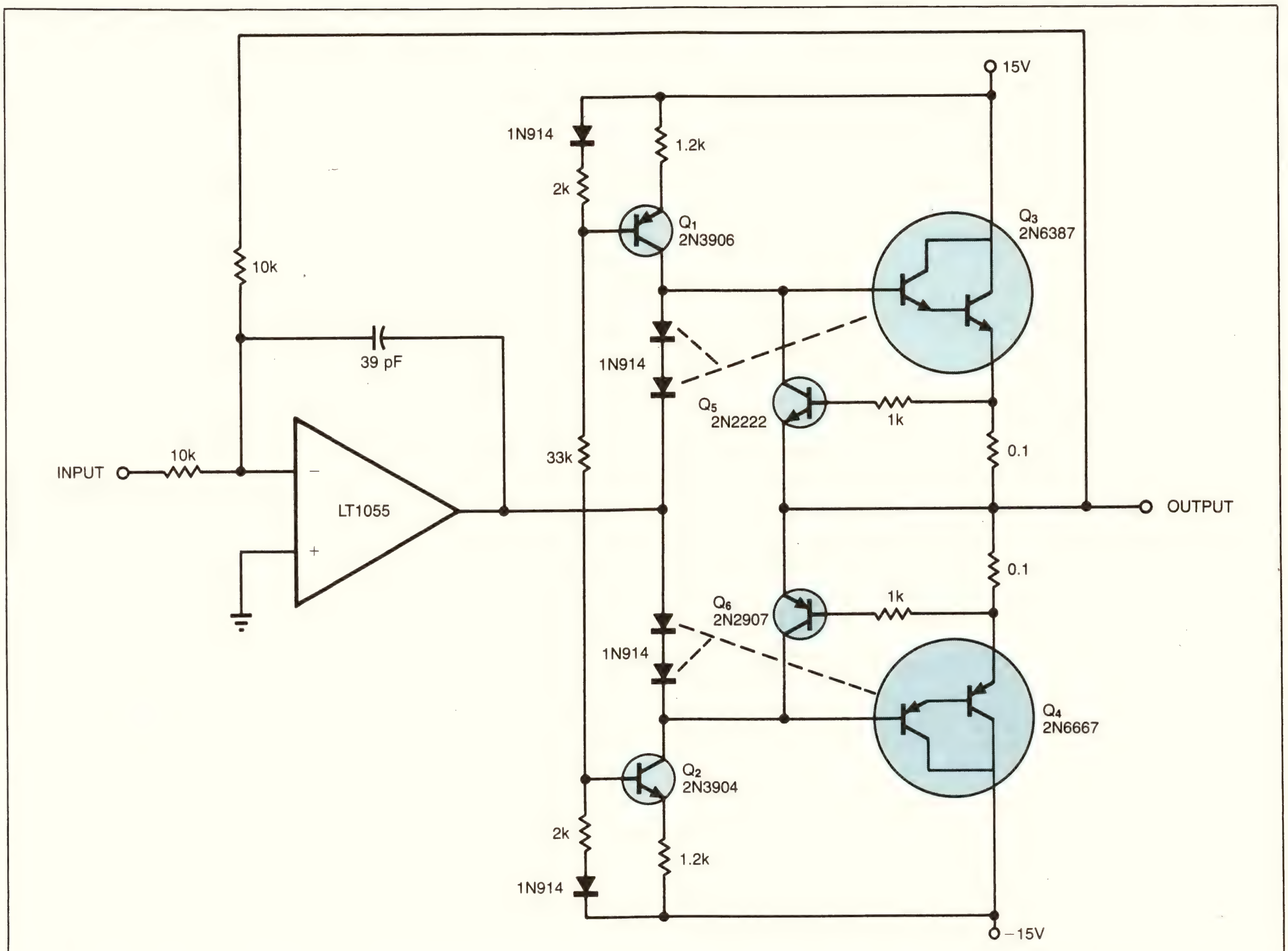


*Fig 3—**Providing a 5A output, this circuit** also features harmonic distortion of 0.05%. The dashed lines indicate that the diodes and transistors must be thermally mated to prevent thermal runaway.*

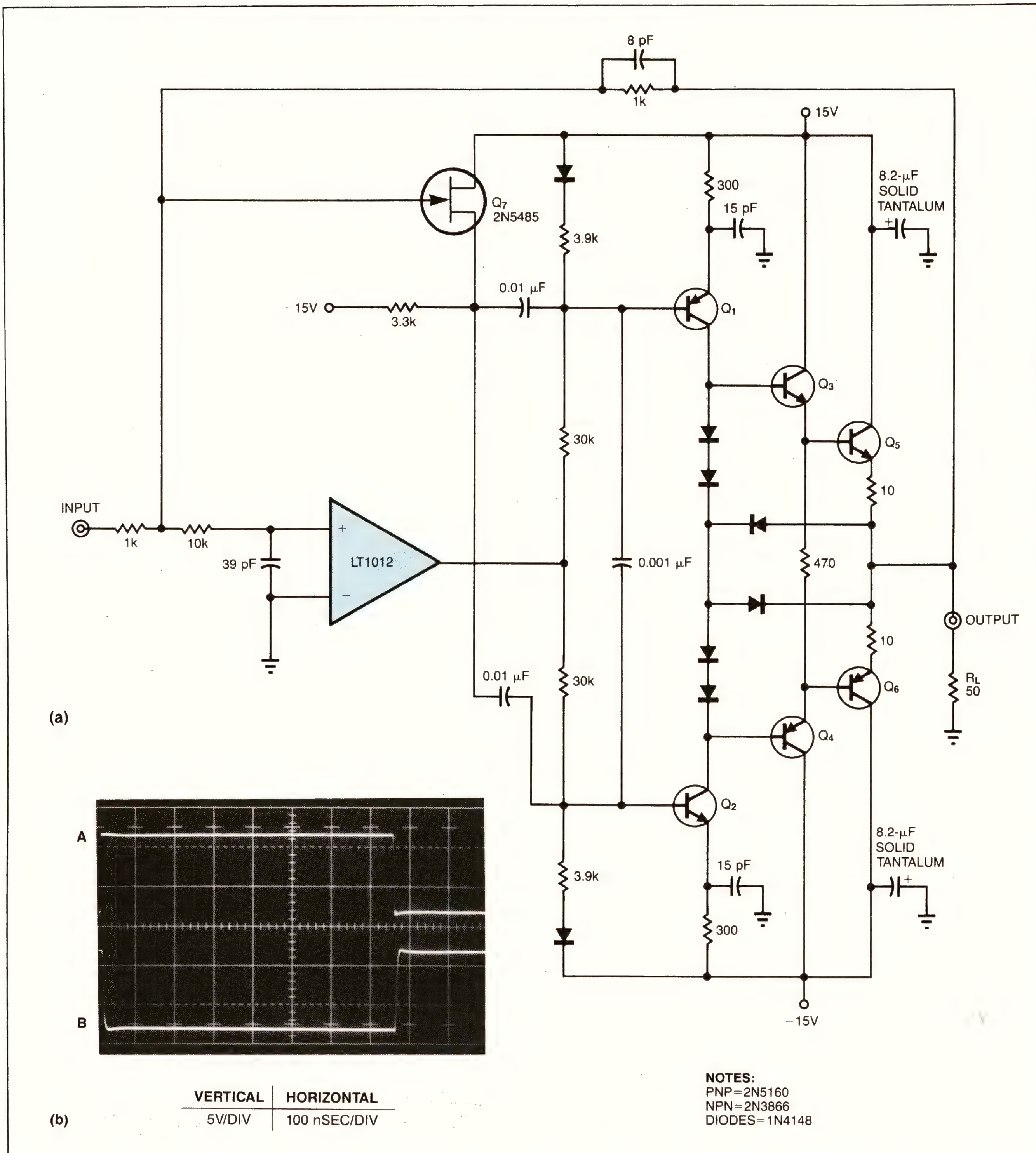


Fig 4—Using a feed-forward technique, *this wideband booster stage* ***(a)*** *exhibits low drift and gain stability. The circuit features a slew rate in excess of 1000V/μsec and a full-power bandwidth of 7.5 MHz. The scope photo* ***(b)*** *shows the circuit driving a 10V pulse into a 50Ω load. Trace A is the input and trace B is the output.*

Voltage-gain stages usually mandate high-voltage power supplies, but output stages that generate their own high voltages are an alternative.

stage's booster within the op amp's feedback loop. Although this placement ensures low drift and good gain stability, the op amp's response limits speed. **Fig 4a** shows a very wideband, current-boost stage. The LT1012 corrects dc errors in the booster stage, but doesn't amplify high-frequency signals. Q_7 and the 0.01-μF coupling capacitors feed fast signals directly to the output stage.

DC and low-frequency signals, on the other hand, drive the stage via the op amp's output. This parallel-path approach allows very broadband performance without sacrificing the dc stability of the op amp, thus boosting the LT1012's output current and speed.

The output stage consists of current sources Q_1 and Q_2 driving the Q_3/Q_5 and Q_4/Q_6 complementary emitter followers. The transistors specified have f_T approaching 1 GHz, resulting in a very fast stage. The diode network at the output steers drive current away from the transistor bases when output current exceeds 250 mA, providing fast short-circuit protection.

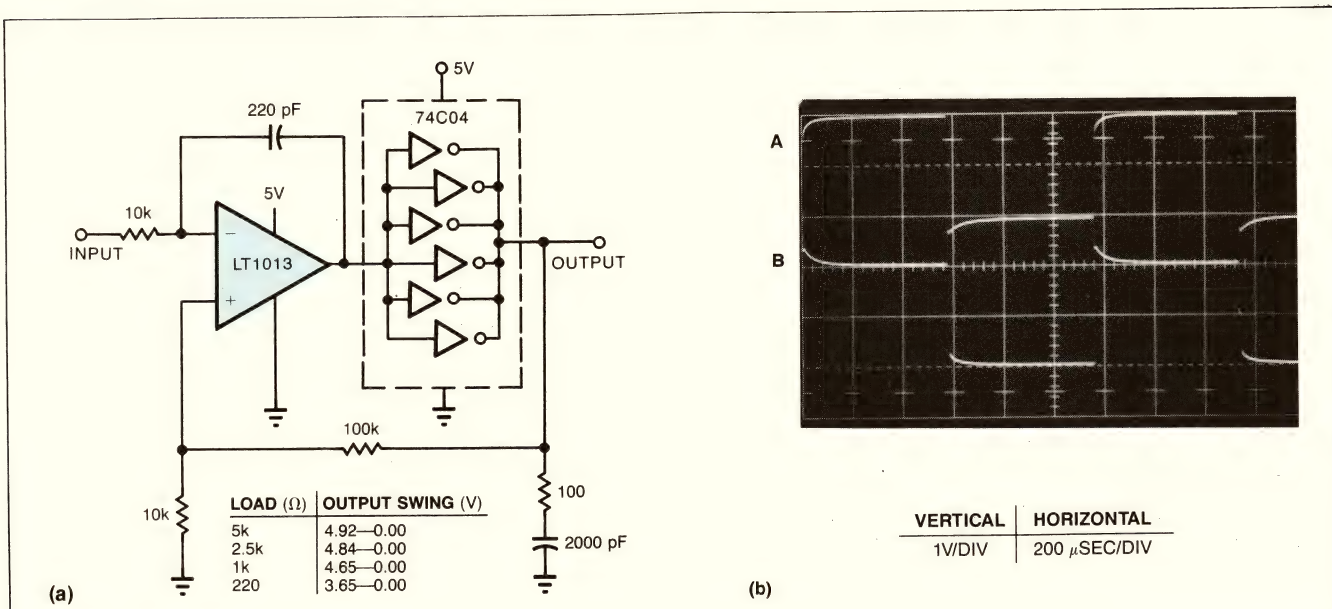
Net inversion in the stage means the feedback must return to the LT1012's positive input. The circuit's high-frequency summing node is the junction of the 1-kΩ and 10-kΩ resistors at the LT1012. The 10-kΩ/39-pF pair filters high frequencies, permitting accurate dc summation at the LT1012's positive input. The low-frequency rolloff of the fast stage matches the high-frequency characteristics of the LT1012 section, minimizing aberration in the circuit's ac response. The 8-pF feedback capacitor optimizes settling characteristics at the highest speeds.

Slew rate exceeds 1000V/μsec

This current-boosted amplifier features a slew rate in excess of 1000V/μsec, a full-power bandwidth of 7.5 MHz, and a 3-dB point of 14 MHz. **Fig 4b** shows the circuit driving a 10V pulse into a 50Ω load. Trace A is the input, and trace B is the output. Slew and settling characteristics are quick and clean, and pulse fidelity approaches the quality of the input pulse generator. Note that this circuit relies on summing action, and you can't use it in the noninverting mode.

An often-needed type of voltage-gain stage is one that allows the output to swing very near the supply rails. **Fig 5a** utilizes the resistive nature of the complementary outputs of CMOS logic inverters to make such a stage.

Although using CMOS inverters in such an application might seem unusual, it's a simple, inexpensive way to extend an amplifier's output swing to the supply rails. This circuit is particularly useful in 5V-powered analog systems, where improvements in available output swing are desirable to maximize signal-processing range.



LOAD (Ω)	OUTPUT SWING (V)
5k	4.92—0.00
2.5k	4.84—0.00
1k	4.65—0.00
220	3.65—0.00

VERTICAL	HORIZONTAL
1V/DIV	200 μSEC/DIV

***Fig 5—This unusual circuit employs paralleled CMOS** logic inverters operating in their linear region. The design is a simple, inexpensive way to extend an op amp's output swing to the supply rails. Note that, in **b**, the op amp's output (trace B) servos around the inverter's switching threshold and that the inverter's output (trace A) swing is quite close to the supply rails.*

An often-needed form of voltage gain stage is one that allows the output to swing very near the supply rails.

The paralleled logic inverters are within the LT1013's feedback loop. The paralleling drops output resistance, aiding swing capability. The inversion in the loop requires that the feedback connection go to the amplifier's positive input. An RC damper eliminates oscillation in the inverter stage, which has a high gain-bandwidth product when running in its linear region.

Local capacitive feedback at the amplifier provides loop compensation. The table in **Fig 5a** shows that the output swing is quite close to the positive rail, particularly at loads below several milliamperes. In a servo action, the LT1013's output (trace A in **Fig 5b**) swings around the 74C04's switching threshold (about half the supply voltage) as it controls the circuit's output (trace B). This servo technique allows the amplifier to operate well within its output-swing range while controlling a circuit output with nearly rail-to-rail capability.

Bipolar stage lowers saturation losses

The configuration in **Fig 6** is similar to **Fig 5a**'s circuit except that the CMOS inverters drive a bipolar output stage to obtain extremely low saturation losses. **Fig 7** plots the circuit's saturation characteristics. If you remove the current-limit circuitry, losses are lowest; however, the output transistors won't tolerate output shorts.

Fig 8a is another rail-to-rail output stage, but this circuit features higher output-current and -voltage capability. The stage's voltage gain and low saturation losses allow it to swing nearly to the rails while supplying current gain.

Q_3 and Q_4, driven by the op amp, provide complementary voltage gain to output transistors Q_5 and Q_6. In most amplifiers, the output transistors are configured

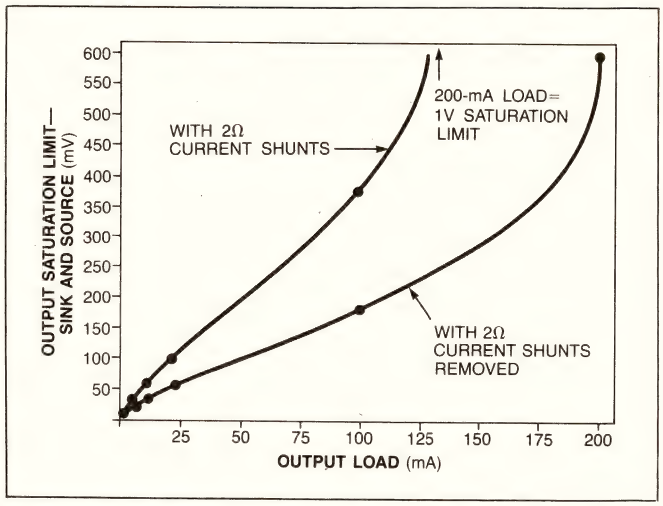


Fig 7—Removing the current shunts from Fig 6's circuit *lowers the circuit's saturation losses, but obviously eliminates short-circuit protection as well.*

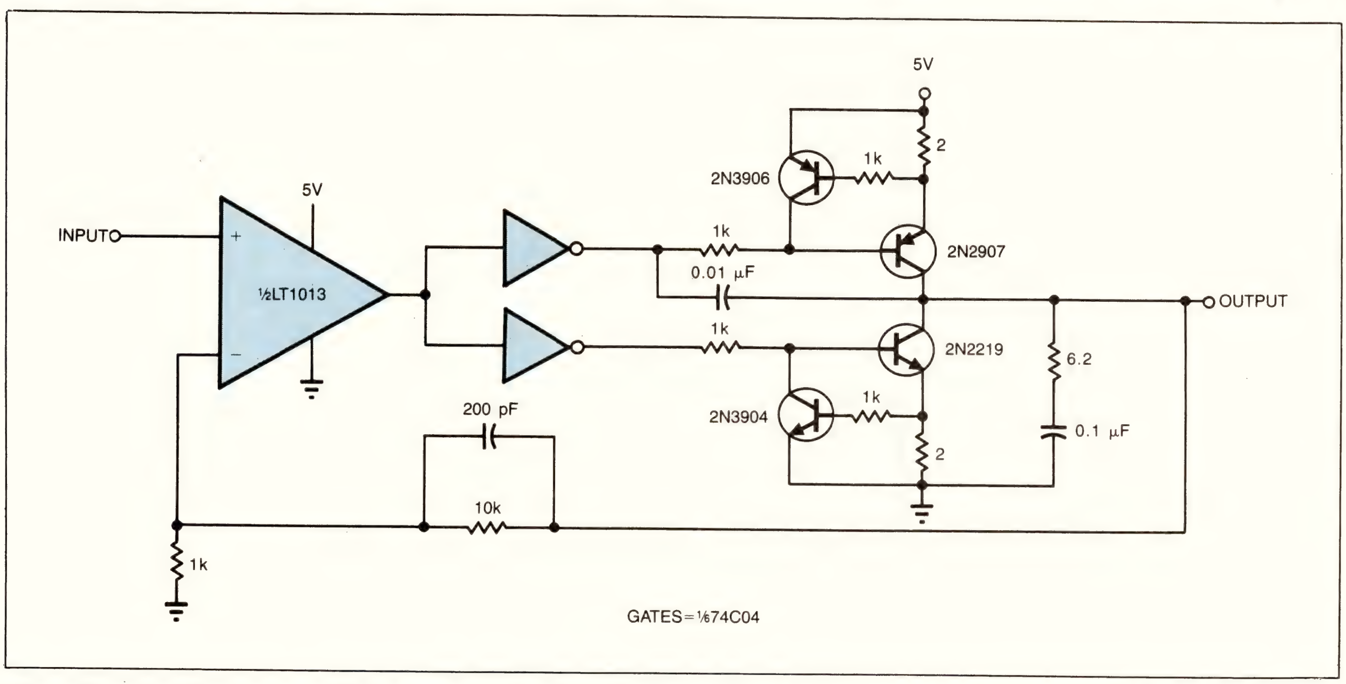
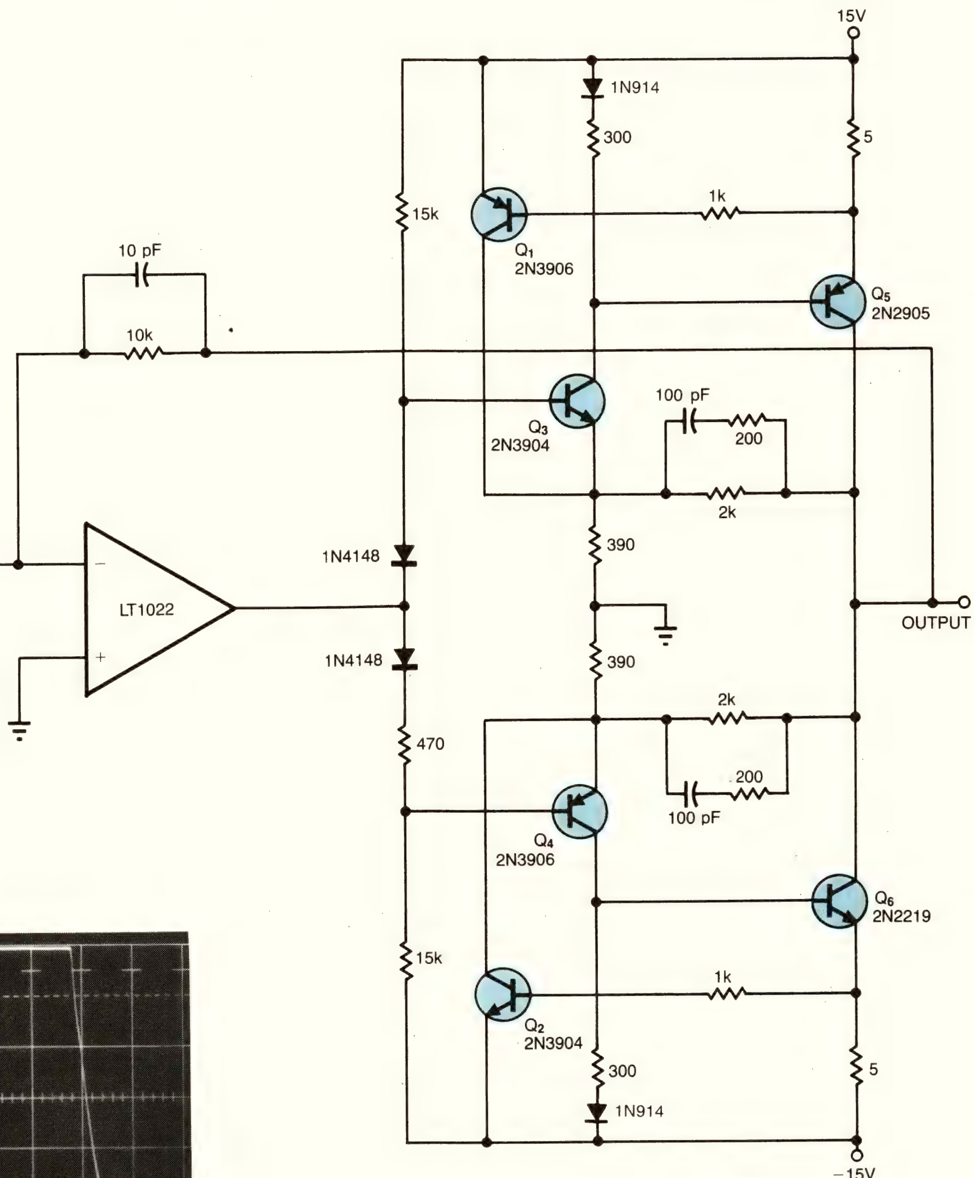
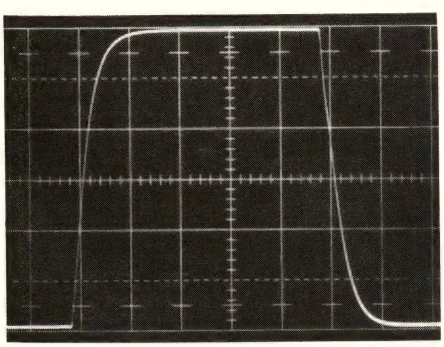


Fig 6—This circuit is similar to Fig 5a's *except that the CMOS inverters drive a bipolar output stage to obtain low saturation losses.*





VERTICAL	HORIZONTAL
5V/DIV	1 μSEC/DIV

(b)

OUTPUT CURRENT	± SWING SATURATION LIMIT
100 μA	100 mV
1 mA	160 mV
10 mA	300 mV
100 mA	600 mV (150 mV WITH CURRENT LIMIT REMOVED)

***Fig 8—This rail-to-rail output stage** features higher output-current and -voltage capability than the one in **Fig 5a**. In response to a bipolar input pulse **(b)**, the circuit swings nearly to the supply rails, exhibiting clean dynamics and good slew rate.*

Obtaining bipolar output from a transformer-based voltage booster requires some form of dc-polarity restoration at the output.

as emitter followers, furnishing current gain. Their V_{BE} drop, combined with voltage-swing limitations of the driving stage, introduce the swing restrictions characteristic of such stages.

Q_5 and Q_6 are in a common-emitter configuration, providing additional voltage gain and eliminating V_{BE} drops as a concern. The voltage inversion of these devices combines with the drive-stage inversion to yield overall noninverting operation. Feedback goes to the LT1022's negative input. The 2-kΩ/390Ω local feedback loop associated with each side of the booster limits stage gain to about five. This limiting is necessary for stability.

The gain-bandwidth product available through the Q_3/Q_5 and Q_4/Q_6 connections is quite high and not readily controllable. The local feedback reduces the gain-bandwidth product, promoting stage stability. The 100-pF/200Ω damper across each feedback resistor provides heavy gain attenuation at very high frequencies, eliminating parasitic local-loop oscillations in the 50- to 100-MHz range. Q_1 and Q_2, sensing across the 5Ω shunts, furnish 125-mA current limiting. Current flow above 125 mA causes the appropriate transistor to turn on, shutting off the Q_3 or Q_4 driver stage.

Even with the feedback-enforced gain-bandwidth limiting, the stage is quite fast. AC performance is comparable to that of the amplifier used to control the stage. Using an LT1022, the circuit achieves full-power bandwidth of 600 kHz and a slew rate exceeding 23V/μsec under 100-mA output loading.

Current sensors are removable

The table in **Fig 8a** gives the swing saturation limit for a given output. Note that, at high current, the 5Ω current-sense resistors, which you can remove, primarily limit output swing. In addition, **Fig 8b** shows the circuit's response to a bipolar input pulse for 25-mA loading. The output swings nearly to the rails, is fast, and has clean dynamic characteristics.

Fig 9a is another voltage-gain output stage. Instead of minimizing saturation losses, however, it provides high-voltage outputs from a ±15V-powered amplifier. Q_1 and Q_2 furnish voltage gain and feed the Q_3/Q_4 emitter-follower outputs. The ±15V for the LT1055 control amplifier comes from the high-voltage supplies via the zener diodes.

Q_5 and Q_6 set current limit at 25 mA by diverting output drive when voltages across the 27Ω shunts

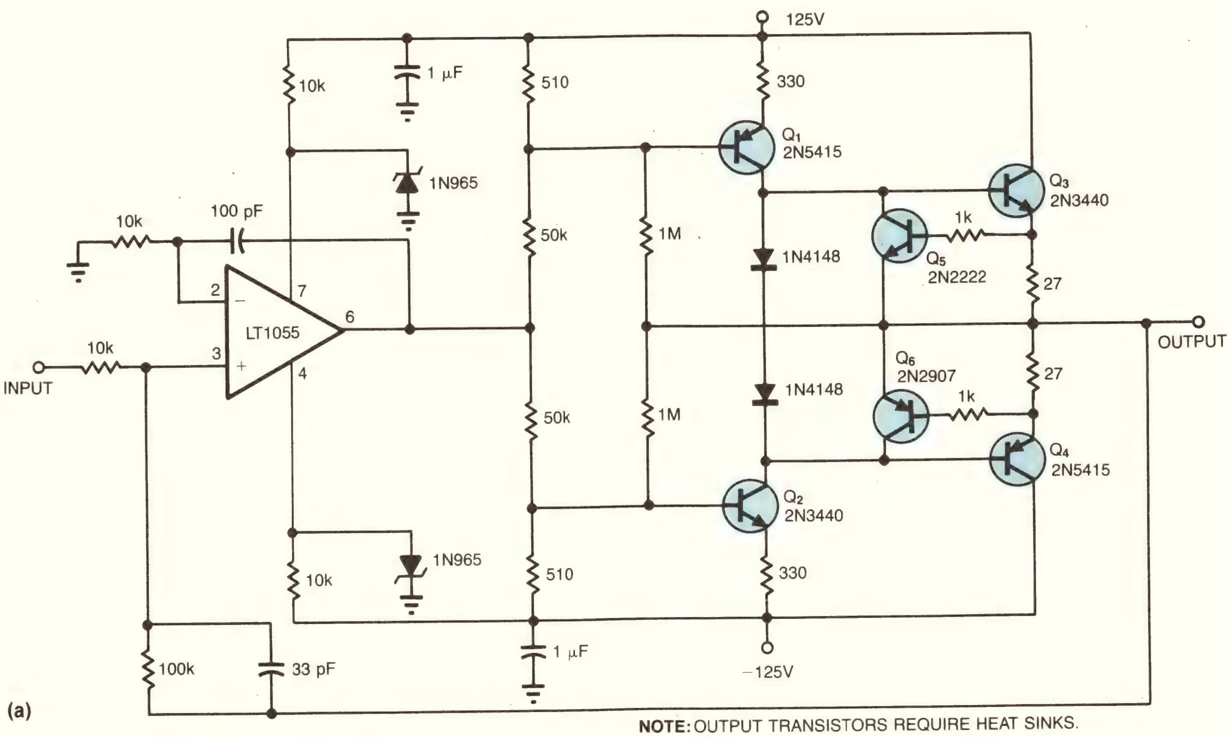
BOOSTER-STAGE CHARACTERISTICS

FIGURE	VOLTAGE GAIN	CURRENT GAIN	FULL-POWER BANDWIDTH	COMMENTS
1a	NO	YES 150 mA	600 kHz	SIMPLE, EASY.
1b	NO	YES 150 mA	1.5 MHz	SIMPLE, EASY.
3	NO	YES 5A	100 kHz	
4a	NO	YES 200 mA	7.5 MHz	FEEDFORWARD TECHNIQUE GIVES HIGH BANDWIDTH. SLEW RATE IS GREATER THAN 1000V/μSEC. INVERTING OPERATION ONLY.
5a	YES	NO	DEPENDS ON OP AMP	SIMPLE STAGE ALLOWS WIDE SWING, ALMOST TO RAILS.
8a	YES	YES 125 mA	600 kHz	HIGH-CURRENT, NEARLY RAIL-TO-RAIL SWING CAPABILITY.
9a	YES ±120V	YES 25 mA	15 kHz	GOOD, GENERAL-PURPOSE HIGH-VOLTAGE STAGE.
10a	YES ±120V	YES 25 mA	12 kHz	ALMOST-INDESTRUCTIBLE OUTPUT.
11a	YES 1000V	NO	60 Hz	HIGH-VOLTAGE OUTPUT; NO EXTERNAL HIGH-VOLTAGE SUPPLIES REQUIRED. LIMITED BANDWIDTH WITH ASYMMETRIC SLEWING. POSITIVE OUTPUTS ONLY.
12a	YES ±100V	YES 150 mA	150 Hz	HIGH-VOLTAGE OUTPUTS; NO EXTERNAL HIGH-VOLTAGE SUPPLIES REQUIRED. LIMITED BANDWIDTH. FULL BIPOLAR OUTPUT.

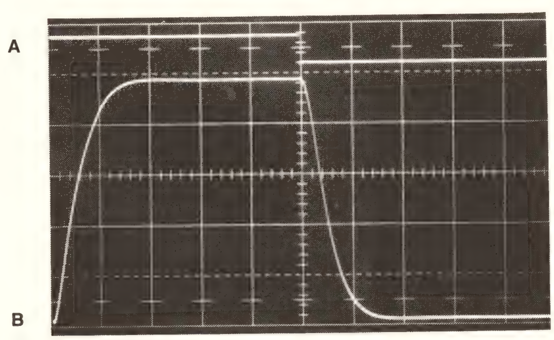
become too high. The local 1-MΩ/50-kΩ feedback pairs set stage gain at 20, allowing the LT1055, supplying by ±10V, to effect a full ±120V output swing. As in **Fig 8a,** the local feedback reduces the stage's gain-bandwidth product, making dynamic control easier.

You can easily provide frequency compensation for this stage because only Q_1 and Q_2 contribute voltage gain. In addition, the high-voltage transistors have large junctions, resulting in low f_Ts, and need no special high-frequency rolloff precautions. Frequency compensation comes from rolling off the LT1055 with the local 100-pF/10-kΩ pair. The 33-pF capacitor in the feedback peaks the output's edge response and isn't required for stability.

Because the stage inverts, feedback goes to the LT1055's positive input. Full-power bandwidth is 15 kHz, and slew limit is about 20V/μsec. As shown, the circuit operates in inverting mode, though you can achieve noninverting operation by exchanging the input and ground assignments at the LT1055's input. Under



NOTE: OUTPUT TRANSISTORS REQUIRE HEAT SINKS.



TRACE	VERTICAL	HORIZONTAL
A	50V/DIV	10 μSEC/DIV
B	50V/DIV (INVERTED)	10 μSEC/DIV

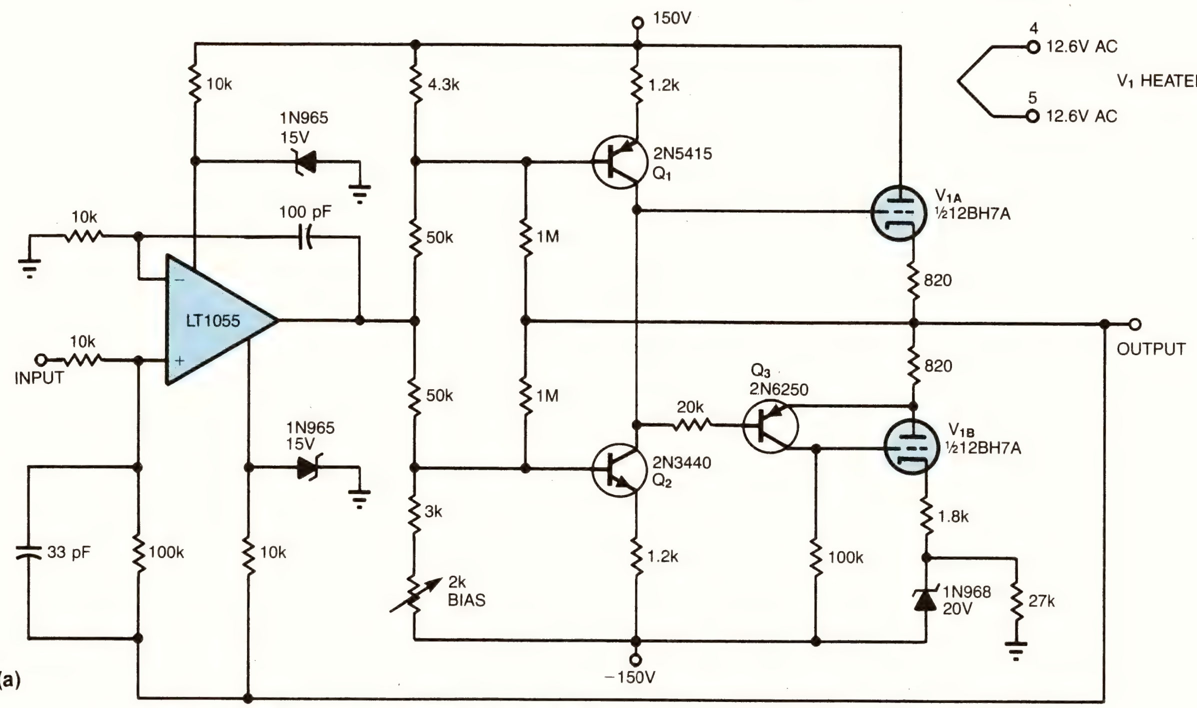
***Fig 9—This design (a) provides high-voltage outputs** from a circuit containing a ±15V-powered op amp. Applying a ±12V pulse (trace A) **(b)**, results in the cleanly damped, 240V peak-to-peak output pulse (trace B).*

A parallel-path approach allows very broadband performance without sacrificing the dc stability of the op amp.

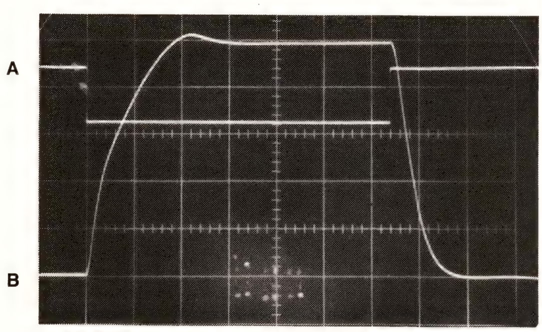
noninverting conditions, you must observe the LT1055's input common-mode-voltage limits and set the minimum noninverting gain at 11.

If you require overcompensation, increasing the 100-pF capacitor's value is preferable to increasing the 33-pF loop-feedback capacitor. Retaining the loop-feedback capacitor prevents excessive high-voltage energy from coupling to the LT1055's inputs during fast slewing. If you must increase the feedback capacitor, you should clamp the summing point with diodes to ground or to the LT1055's supply terminals. **Fig 9b** shows the circuit's response to a ±12V input pulse (trace A). The output (trace B) responds with a cleanly damped, 240V p-p pulse.

Fig 10a is a similar stage, except that it replaces **Fig 9a's** output transistors with vacuum tubes. Most of this stage is conceptually identical to **Fig 9a,** but minor changes are necessary to get the vacuum tubes' output to swing negatively. Replacing **Fig 9a's** npn emitter follower with a cathode follower (V_{1A}) readily achieves a positive swing. The circuit needs the transistor inverter (Q_3) because our thermionic friends have no equiva-



(a)

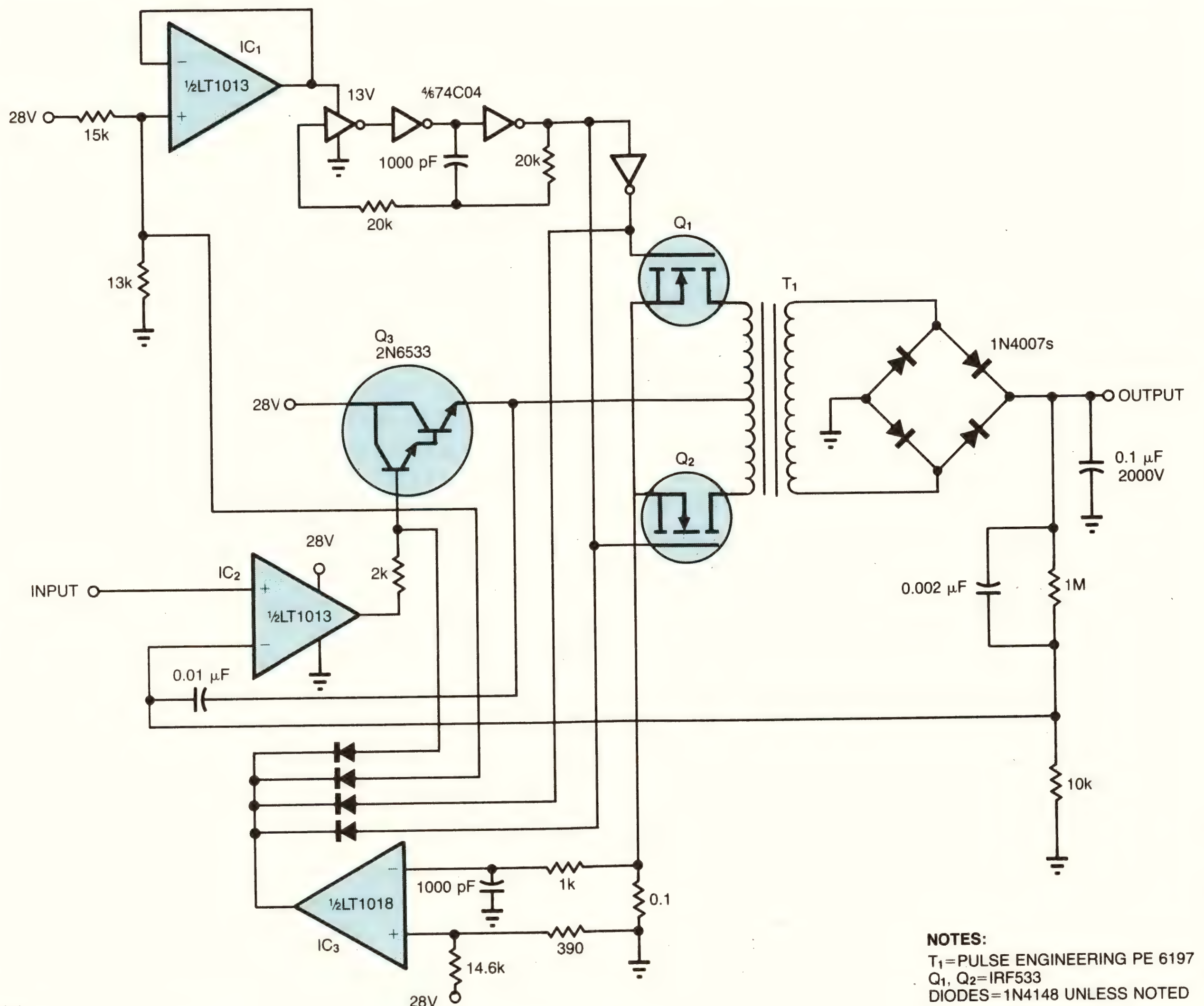


TRACE	VERTICAL	HORIZONTAL
A	20V/DIV	10 μSEC/DIV
B	50V/DIV	10 μSEC/DIV

(b)

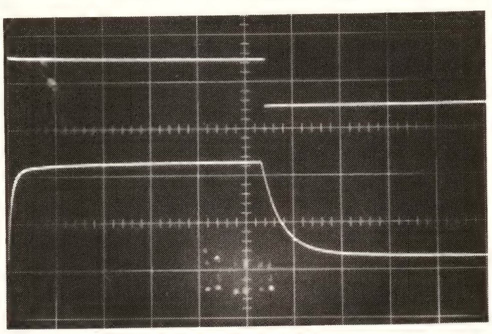
Fig 10—By replacing Fig 9a's transistors with vacuum tubes (a), *you can achieve a rugged and very forgiving op-amp booster with very high-voltage capability. Note that although the circuit's response to a bipolar input is clean and sharp, the stage's asymmetric gain-bandwidth product produces different responses to the leading and trailing edges of the input* ***(b).***

(a)



A

B



(b)

TRACE	VERTICAL	HORIZONTAL
A	10V/DIV	5 mSEC/DIV
B	500V/DIV	5 mSEC/DIV

Fig 11—If you need only unipolar outputs, *this circuit provides 1000V output swings (for a 10V input), supplies 15W, and requires no separate high-voltage supply—it generates its own high voltage. In* ***b,*** *note that the slewing is faster on the leading edge than the trailing edge of the output pulse (trace B) because the stage cannot sink current. The load resistance determines the falling edge's slew rate.*

The amount of skew is both load and signal-frequency dependent and isn't readily compensated.

lent to pnp transistors. Zener biasing of V_{1B}'s cathode allows Q_3's swing to cut off the tube, a depletion-mode device.

Without correction, the dc-biasing asymmetry, caused by the Q_3 and V_{1B} configuration, will force the LT1055 to bias well away from 0V. Tolerance stack-up could cause saturation limiting in the LT1055's output, reducing overall available swing. Skewing the stage's bias string with the potentiometer adjustment avoids this reduction. To make this adjustment, you need to ground the input and trim the potentiometer for 0V at the LT1055's output.

Fig 10a's full-power bandwidth is 12 kHz, and its slew rate is about 12V/μsec. **Fig 10b** shows the circuit's response to a bipolar input (trace A). The output responds cleanly, although the slew and settling characteristics reflect the stage's asymmetric gain-bandwidth product. This stage's output is extremely rugged because of the inherent forgiving nature of vacuum tubes. It needs no special short-circuit protection, and the output will survive shorts to voltages many times the value of the ±150V supplies.

Gain stage has a unipolar output

Fig 11a shows a unipolar output gain stage that swings 1000V and supplies 15W. Only unipolar operation is possible because the step-up transformer can't pass dc-polarity information. This booster stage has the highly desirable property of operating from a single, low-voltage supply. It doesn't require a separate high-voltage supply; instead, a switching converter (which is an integral part of the gain stage) directly generates the high voltage.

IC_2's output drives Q_3, forcing current into T_1. MOSFETs Q_1 and Q_2, which receive complementary drive from the 74C04-based square-wave oscillator, chop T_1's primary current. IC_1 supplies power to the oscillator. T_1 provides voltage step-up. T_1's rectified and filtered output is the booster stage's output.

The 1-MΩ/10-kΩ divider furnishes feedback to IC_2, closing a loop around it. The 0.01-μF capacitor from Q_3's emitter to IC_2's negative input provides loop stability, and the 0.002-μF unit trims step-response damping.

Comparator IC_3 provides short-circuit limiting. Current from Q_1 and Q_2 passes through the 0.1Ω shunt, which develops the error signal for IC_3. Abnormal output currents cause the shunt voltage to rise, tripping IC_3's output low. This tripping simultaneously removes drive from Q_3, Q_1, and Q_2's gates as well as the oscillator, resulting in output shutdown. The 1-kΩ/1000-pF filter ensures that IC_3 does not trip during normal operation because of current spikes or noise.

FETs work down to 0V

IC_2 supplies whatever drive is required to close the loop, regardless of the output voltage called for. The low, resistive-saturation losses of the VMOS FETs combined with IC_2's servo action allows controlled outputs all the way down to 0V.

Substituting higher power devices for Q_1 and Q_2 along with a larger transformer allows more output power, although dissipation in Q_3 will become excessive. If you desire even higher power, you should substitute a switched-mode stage for Q_3 to maintain efficiency.

The 0.1-μF filter capacitor at the output limits full-power bandwidth to about 60 Hz. **Fig 11b** shows the circuit's dynamic response at full load. Trace A, a 10V input, produces a 1000V output in trace B. Note that slewing is faster on the leading edge because the stage can't sink current. The load resistance determines the falling edge's slew rate.

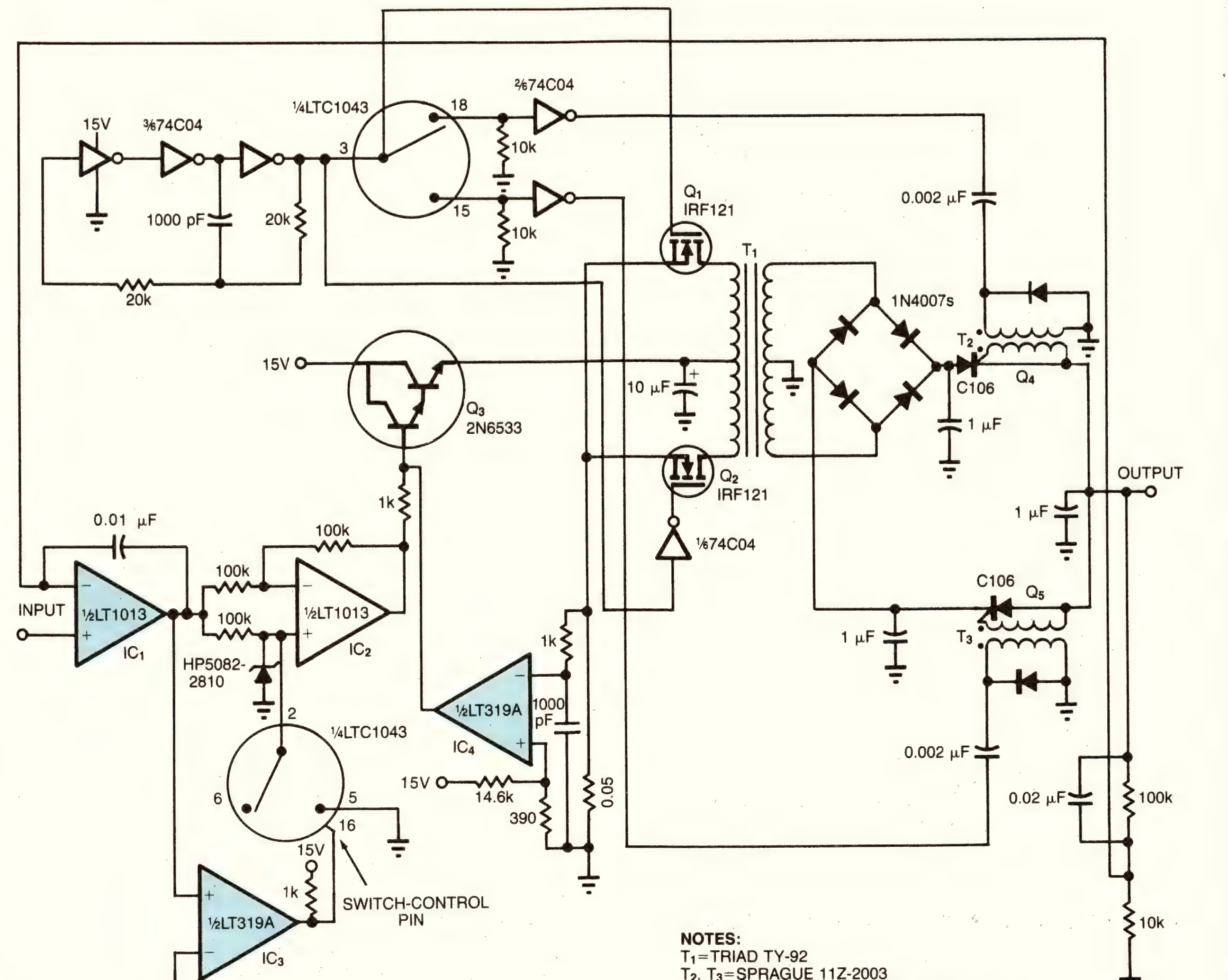
Obtaining bipolar output from a transformer-based voltage booster requires some form of dc-polarity restoration at the output. **Fig 12a**'s ±15V-powered circuit provides this restoration, using synchronous demodulation to preserve polarity in its ±100V output. This booster features 150-mA current output, 150-Hz full-power output, and 0.1V/μsec slew rate.

The high-voltage output's generation is similar to that in **Fig 11a**'s circuit. The 74C04-based oscillator furnishes bipolar gate drive to VMOS devices Q_1 and Q_2, which chop Q_3's output into T_1, a step-up transformer. In this design, however, a synchronously switched, absolute-value amplifier sits between servo amplifier IC_1 and Q_3's drive point.

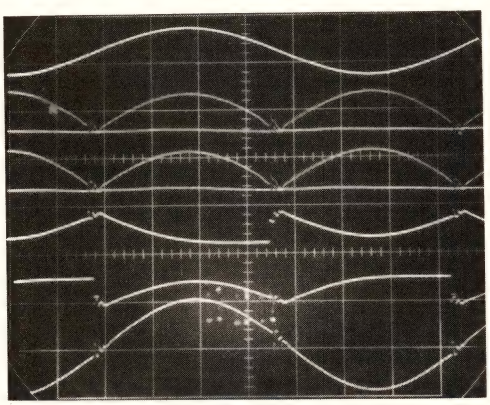
Input-signal polarity information, derived from IC_1's output, causes comparator IC_3 to switch the LTC1043 section located at IC_2's positive input. In this circuit, IC_2's output is the positive absolute value of IC_1's input signal. A second, synchronously switched, LTC1043 section gates the oscillator's pulses to the appropriate SCR's trigger transformer at the output. Positive inputs cause pin 2 to connect to pin 6, as well as pin 3 to pin 18, in the LTC1043.

Comparator IC_4 supplies current limiting in identical fashion to **Fig 11a**'s scheme. Frequency compensation is also similar. A 0.01-μF capacitor at IC_1 provides loop stability, and the 0.02-μF feedback unit sets damping.

IC_2, acting as a unity-gain follower, passes IC_1's

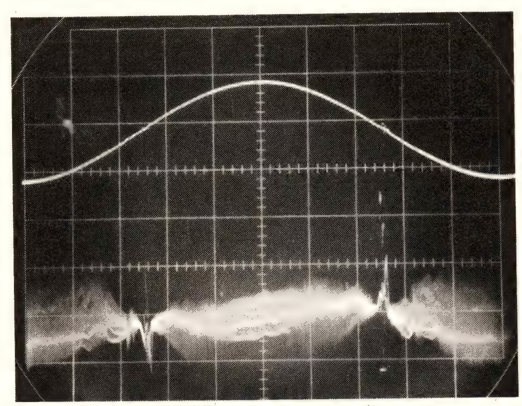


(a)

A
B
C
D
E
F


TRACE	VERTICAL	HORIZONTAL
A	10V/DIV	5 mSEC/DIV
B	20V/DIV	5 mSEC/DIV
C	20V/DIV	5 mSEC/DIV
D	100V/DIV	5 mSEC/DIV
E	100V/DIV	5 mSEC/DIV
F	50V/DIV	5 mSEC/DIV

(b)

A
B


TRACE	VERTICAL	HORIZONTAL
A	100V/DIV	10 mSEC/DIV
B	0.2V/DIV (1% DISTORTION)	10 mSEC/DIV

(c)

Fig 12—Obtaining bipolar output from a transformer-based *voltage booster requires dc-polarity restoration. This circuit **(a)** uses synchronous demodulation to preserve polarity in its ±100V output. Except for some distortion at the zero crossover caused by phase skewing between the SCR switching and the carrier-borne signal **(b)**, trace F shows an amplified, reconstructed version of the sine-wave input (trace A). Traces B and C are the FETs' drain waveform; traces D and E are the full-wave bridge's negative and positive outputs. At a full load of ±100V and 150 mA peak, the circuit produces the distortion products in trace B **(c)**. You can see residual, high-frequency-carrier components, and the zero-point SCR switching causes the sharp peaks.*

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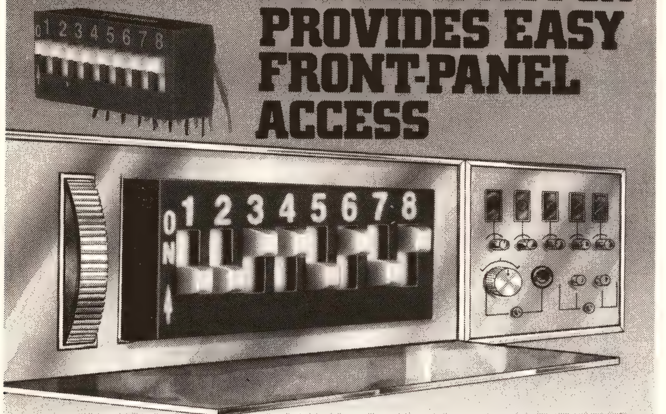

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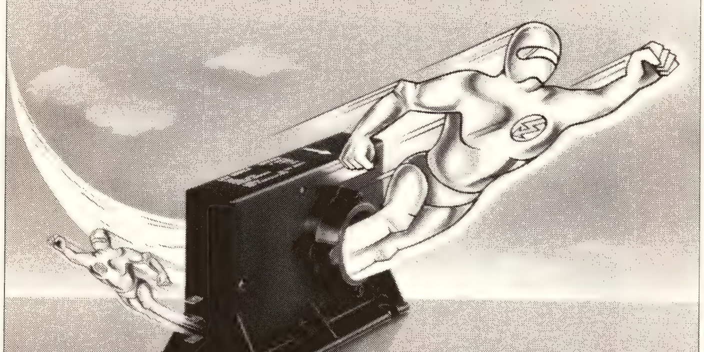

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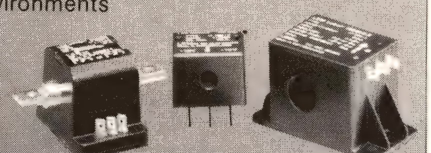

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output directly and drives Q_3. Simultaneously, oscillator pulses conduct through an inverter via LTC1043 pin 18. The inverter drives trigger transformer T_2, turning Q_4 on. Q_4, biased from the full-wave bridge's positive point, supplies positive polarity voltage to the output.

Negative inputs cause the LTC1043 switch positions to reverse. IC_2, functioning as an inverter, again supplies Q_3 with positive voltage drive. The Schottky diode at IC_2 prevents the LTC1043 from seeing transient negative voltages. Oscillator pulses go to SCR Q_5 via LTC1043 pin 15, its associated inverter, and T_3.

Q_5 connects the full-wave bridge's negative point to the output. Both SCRs, tied together, form the circuit's output. The 100-kΩ/10-kΩ divider supplies feedback to IC_1 in the conventional manner. The synchronous switching preserves polarity information from the stage's output, permitting bipolar operation.

Fig 12b shows waveforms for a sine-wave input. Trace A is IC_1's input. Traces B and C are Q_1 and Q_2's drain waveforms. Traces D and E are the full-wave bridge's negative and positive outputs, respectively. Trace F, the circuit output, is an amplified, reconstructed version of IC_1's input. Phase skewing between the SCR switching and the carrier-borne signal causes some distortion at the zero crossover. The amount of skew is both load and signal-frequency dependent and is not readily compensated.

Fig 12c shows distortion products (trace B) at 10 Hz output (trace A) at full load (±100V at 150 mA peak). Residual, high-frequency-carrier components are clearly present, and the zero-point SCR switching causes the sharp peaks. RMS distortion measures 1% at 10 Hz, rising to 6% at 100 Hz. **EDN**

Author's biography

Jim Williams, staff scientist at Linear Technology Corp (Milpitas, CA), specializes in analog-circuit and -instrumentation design. He has served in related capacities at National Semiconductor Corp, Arthur D Little Inc, and the Instrumentation Development Lab at MIT. A former student of psychology at Wayne State University, Jim enjoys tennis, art, and collecting antique scientific instruments.

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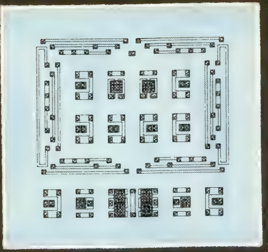

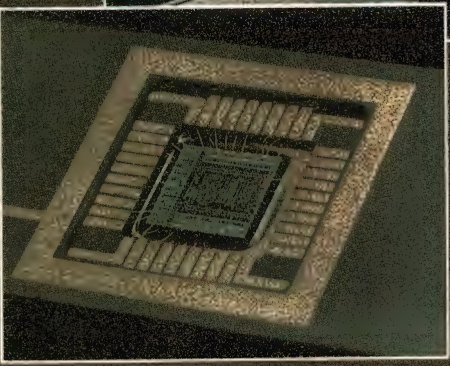

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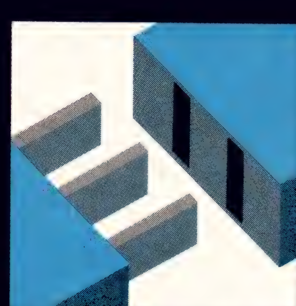

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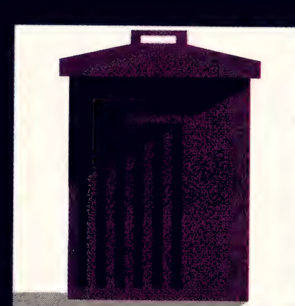

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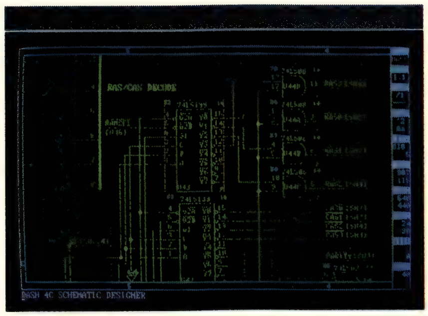

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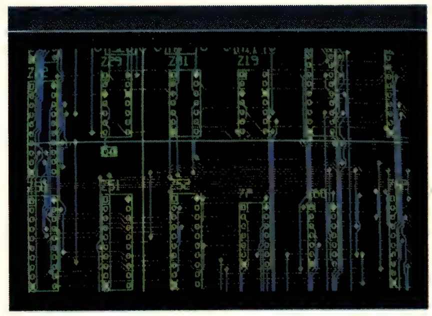

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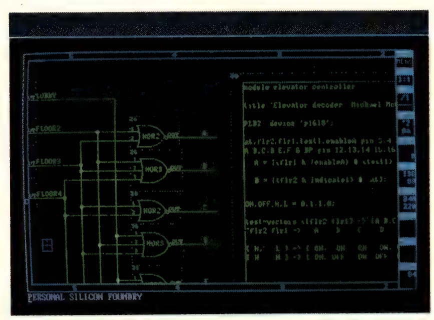

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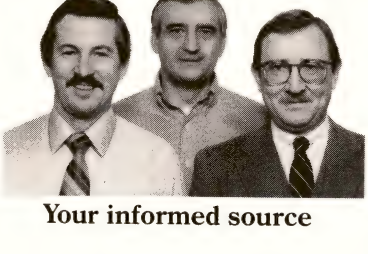

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These precision amplifiers can provide good signal conditioning for thermocouples, for example. Despite their advantages—low cost, high reliability, and the ability to measure wide temperature ranges—thermocouples are somewhat difficult to deal with electrically, because they have low output signal levels and require an ice-point reference. Typical thermocouple output signal levels (on the order of tens of microvolts per degree C) dictate that the signal-conditioning amplifiers used with thermocouples must have input offset and drift specifications well below those levels. You need such specs especially if you want to realize resolution and repeatability to a fraction of a degree.

The circuit in **Fig 1** readily amplifies thermocouples' low-level output signals. The MAX422 has a maximum input drift spec of 50 nV/°C, so the amplifier contributes only 0.001° of output error for each degree of shift in ambient temperature. Because the op amp can use ±15V power supplies, the design is simple: A basic inverting summing network combines the thermocouple output, cold-junction compensation, and cold-junction offset.

The trim procedure is also very simple, because gain and cold-junction adjustments don't interact. This lack of interaction is a significant advantage in multichannel setups, which are fairly common in thermocouple measurement systems.

The small-signal npn transistor provides ice-point compensation for the thermocouple. It generates a

Signal-conditioning amplifiers used with thermocouples must have input offset and drift specifications well below typical thermocouple output signal levels.

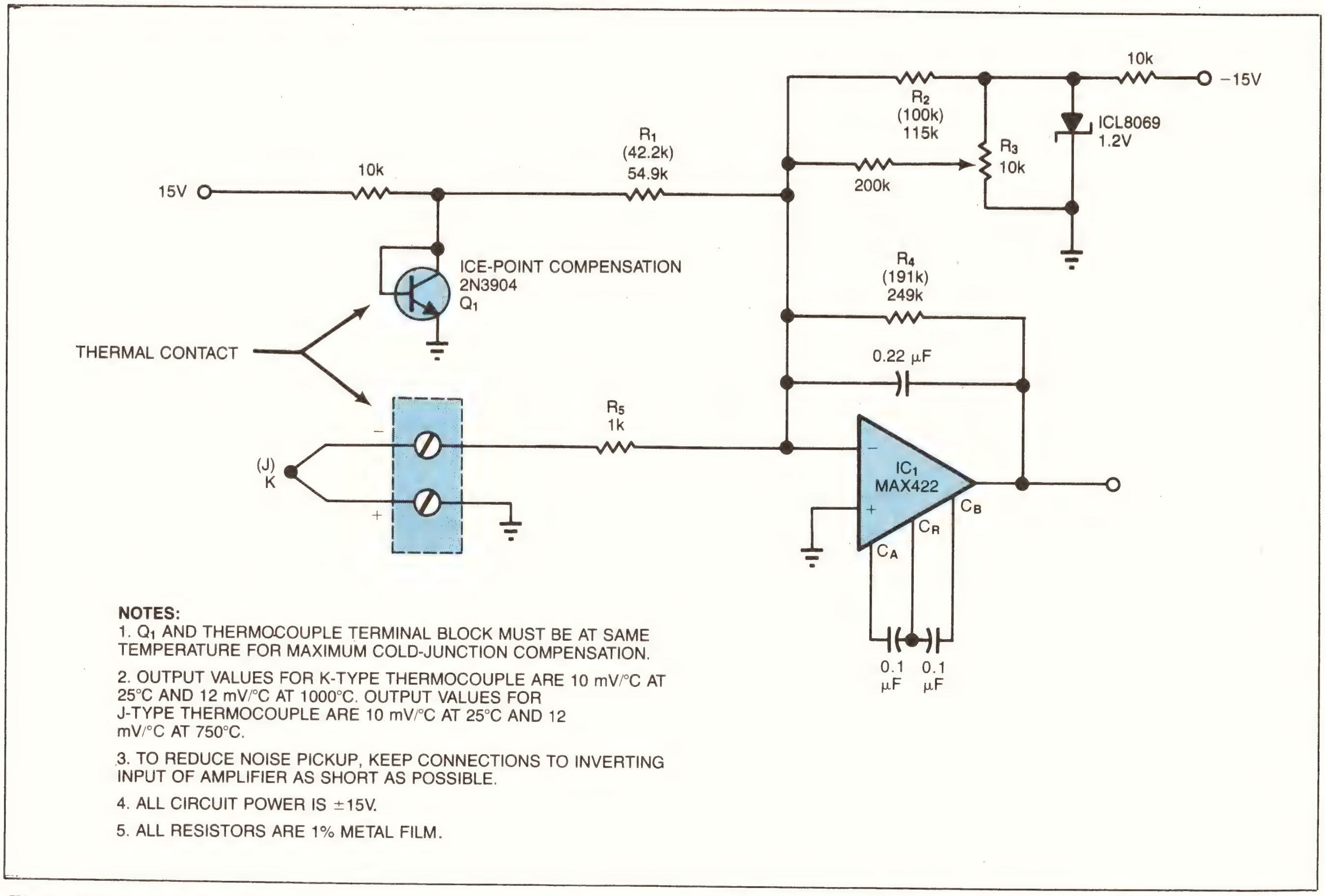


Fig 1—This simple signal-conditioning circuit *uses an inverting summer to combine thermocouple output, cold-junction compensation, and cold-junction offset signals. The circuit is easy to trim, because the gain and cold-junction offset adjustments do not interact.*

−2.2 mV/°C signal, which cancels the thermoelectric error signals generated at the thermocouple's input terminal strip. You should place the transistor as close as possible to the terminal block; to achieve optimum performance, you need to effect thermal contact between the devices.

For temperatures below 200°C (with a common type K thermocouple), the circuit in **Fig 1** provides a 10 mV/°C output. The circuit includes no linearization, so this output factor will change at higher temperatures—12 mV/°C (for type K thermocouples) at 1000°C. Although the circuit component values shown are for J- and K-type thermocouples only, the circuit can accommodate other types of thermocouples. To provide gain and cold-junction compensation, you simply have to calculate new values for R_1, R_2, and R_4.

Platinum resistance thermometers (PRTs) present another classical transducer-conditioning problem. By using platinum wire as the sensing element in a PRT, you can achieve very high accuracy and repeatability over a wide operating-temperature range. As a result, PRTs are well suited for high-accuracy thermometry applications. Like thermocouples, PRTs have a major drawback, however: They provide a low-level output signal. Although the change in resistance over temperature of platinum wire is very predictable, it's also very small (0.3815%/°C), so you'll require large precise gain and long-term stability in order to develop a useful output.

The PRT amplifier circuit in **Fig 2** uses a 3-terminal sensing scheme to eliminate errors from lead resistance, so you can remotely locate the sensor. In addition, the circuit design refers the sensor output to ground, thus minimizing noise-pickup problems. With a 30V supply, the circuit provides a 4- to 20-mA current output with compliance from 3 to 28V.

The REF-01 10V reference combines with IC_1 to generate a precise constant current that biases the PRT

and also creates fixed voltages for sensor-offset correction and wire-resistance error cancellation. Lead-resistance effects (RW_1, RW_2, and RW_3) are subtracted from the real temperature signal at the input of the PRT amplifier, IC_2. The circuit in **Fig 2** works on the principle that the resistance of all three leads will be identical. The lead-resistance effects related to RW_2 are insignificant, however, because only op-amp bias current passes through RW_2.

The temperature and correction signals sum at IC_2 as follows: The voltages on the PRT and its ground wire (RW_3) are amplified by 1, the voltage drop on the PRT's positive lead (RW_1) is amplified by $-\frac{1}{2}$, and the drop across R_4 (an offset resistor) and RW_1 is amplified by $-\frac{1}{2}$. As a result, the RW terms cancel, and the net output appearing across R_3 is the PRT voltage minus ½

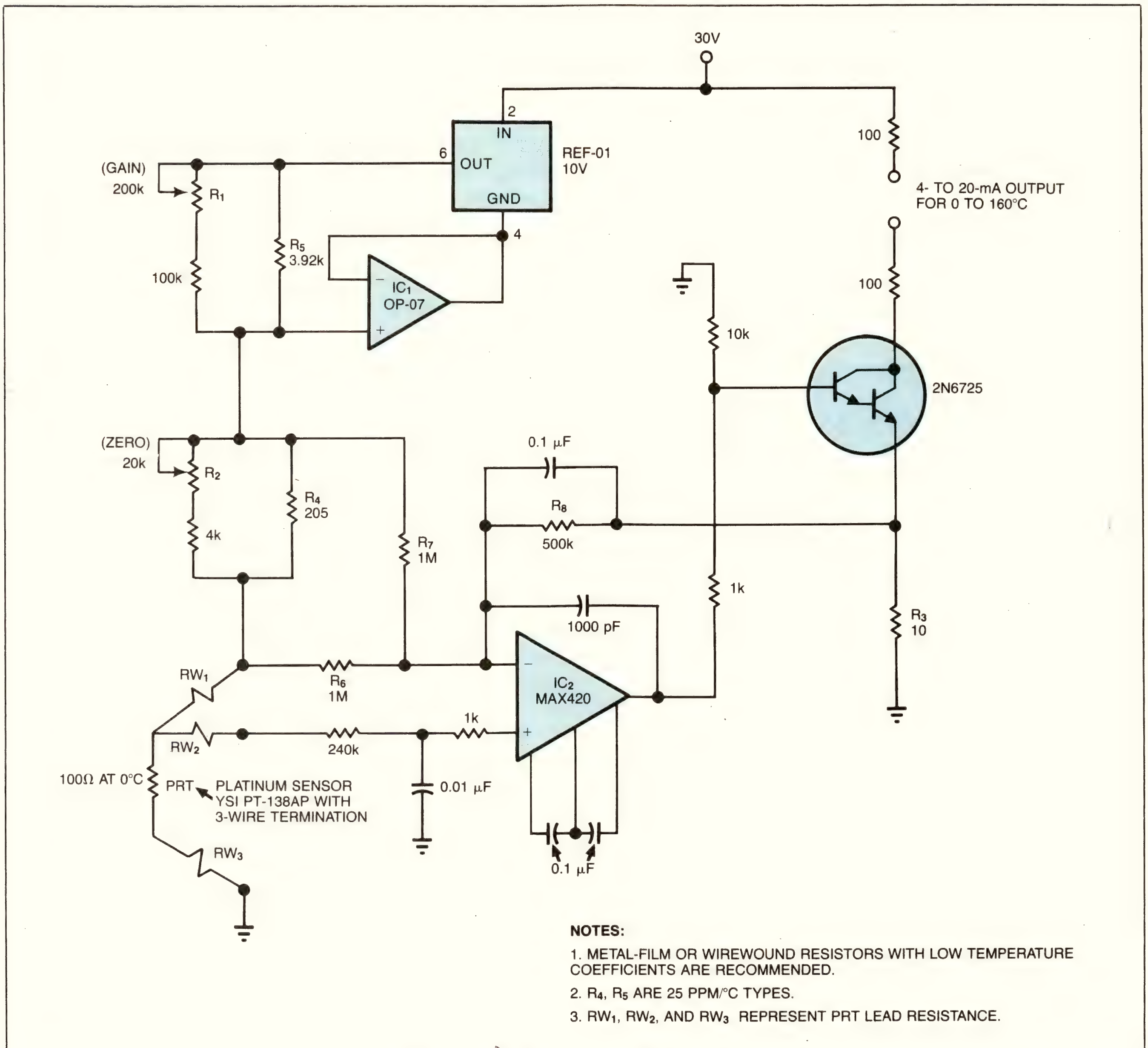


Fig 2—By referring the sensor to circuit ground, *this platinum-resistance-thermometer amplifier circuit minimizes noise-pickup problems. Because the circuit uses a 3-terminal sensing scheme to eliminate errors from lead resistance, you can remotely locate the sensor.*

Because they require high measurement accuracy and low signal levels, bridge-type transducers usually need precise amplification.

the offset on R_4. IC_2 drives a Darlington transistor (Q_1); R_3 senses Q_1's output current to provide a feedback signal for IC_2.

To calibrate the circuit, you must adjust R_2 and R_1. R_2 trims the sensor's offset, and R_1 handles circuit gain adjustments. If you adjust the offset first, the gain trim will not interact, so you can probably make each adjustment in only one pass.

Better precision for instrumentation amps

Precision amplifiers are usually a necessity in applications involving bridge measurements (strain gauges, load cells, and some types of pressure transducers), because these applications require high accuracy and low signal levels. In most cases, instrumentation amplifiers can easily handle the 30-mV differential output signals from these bridge-type devices. These instrumentation amplifiers have finite, controllable, differential gain that's fixed or that can be set with one or two resistors.

The high-performance instrumentation-amplifier circuit in **Fig 3** amplifies a small differential signal from a strain-gauge bridge into a large ground-referenced signal. Such a configuration is typical of off-the-shelf instrumentation amplifiers; however, when you use MAX421 amplifiers in the front end, the offset and drift performance you obtain is better by an order of magnitude than that available in off-the-shelf amplifiers.

As with all instrumentation amplifiers employing this 3-stage configuration, the front-end and output amplifiers will both affect overall drift performance. The output amplifier's effect on drift (referred to the input) is divided by the front-end gain, which is approximately 30 (the overall gain is 300). The MAXOP07's V_{OS} specifications (75 μV and 1.3 μV/°C) are divided and added to two times the MAX421 error, yielding a maximum input-referred error of 12.5 μV and 0.15 μV/°C. Even when front-end gain is set at 30, the MAXOP07 contributes more to offset error than do the MAX421s.

The chopping circuits of the front-end op amps are locked together via their clock-control pins. IC_1's INT/EXT clock pin is unconnected, so it operates from its internal 400-Hz clock in normal fashion. The CLK IN pin of IC_1 functions as an output. Since IC_2's INT/EXT

Addressing thermal problems

In an instrumentation amplifier circuit—as in any design dealing with low-level signals—the quest for microvolt-offset and nanovolt-drift performance involves more than just selecting a high-precision amplifier. When you're trying to amplify low-level signals, any number of outside error sources can complicate your task. These errors are troublesome because it's very hard to distinguish them from real signals or amplifier error.

Thermoelectric voltages provide a perfect example of such error sources. The same phenomenon responsible for thermocouple operation can generate significant errors at pin-to-socket, socket-to-board, and board-to-edge-connector interfaces, and even at soldered connections. The level of the voltage generated in such situations can range from one-tenth to tens of microvolts per degree C. In general, designers deal with this problem by minimizing the use of sockets and connectors in low-level circuitry, or by using components designed for low thermal EMF.

Although temperature obviously contributes to thermoelectric errors, thermal gradients in low-level circuitry cause more problems than does the mere presence of heat. Gradients can, for example, cause the normally balanced input connections of a sensitive amplifier to be at different temperatures. These connections then generate different values of thermoelectric voltages that the amplifier's inputs can no longer completely cancel; the final output is an offset error. The most effective way to combat thermal gradients is to keep power dissipation low and minimize air currents in and around low-level circuitry and connections.

You can also solve thermoelectric voltage problems by designing thermal symmetry into the circuit layout. This solution can involve adding dummy resistors and connections so that the thermal mass—as well as the number of thermoelectric error sources in an input pair—will cancel. In addition, you might have to run input traces close to each other and keep their dimensions identical. You might also find it helpful to develop some thermal filtering by minimizing enclosure size, or by insulating sensitive areas.

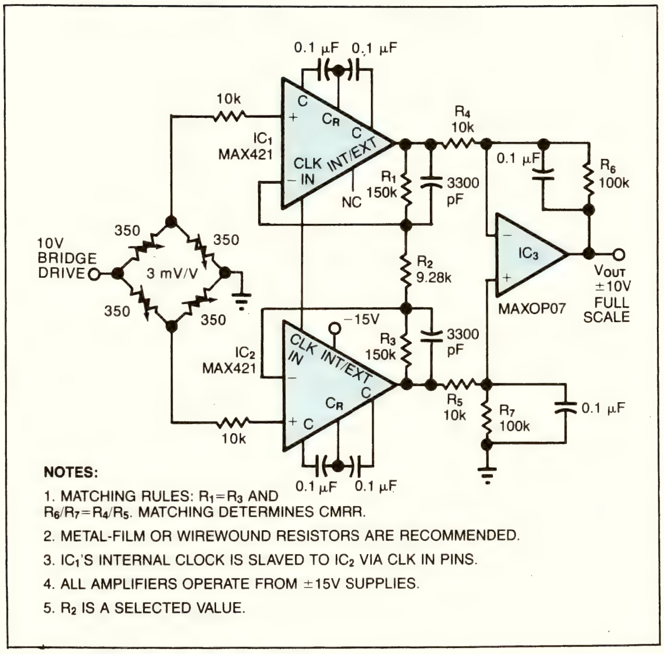


Fig 3—To eliminate the low-level errors caused by clock interaction, *this instrumentation-amplifier circuit locks the chopping circuits of the two front-end op amps together.*

CLK pin is connected to the negative supply, its clock is disabled. IC_1's CLK IN terminal drives IC_2. By synchronizing the input amplifiers in this manner, you eliminate low-level errors caused by clock interaction.

Gain-setting resistor matching limits the amount of common-mode rejection that you can realize. For prototype or test purposes, you can generally achieve 0.1 to 0.01% matching when you use selected 1% resistors. For more precise matching, you'll have to use resistor arrays or resistors that have low temperature coefficients and tighter tolerances. Once you've satisfied your rejection needs, you can adjust R_2 to change overall circuit gain without affecting common-mode-rejection performance.

Amplifying high-level signals

If you're designing circuitry to handle high-current measurements, you'll typically need to use sense resistors, so you'll have to contend with increased power-supply source impedance, and possibly even high power dissipation. Because it uses a low-offset amplifier in a high-current application, the circuit in **Fig 4** eliminates these concerns.

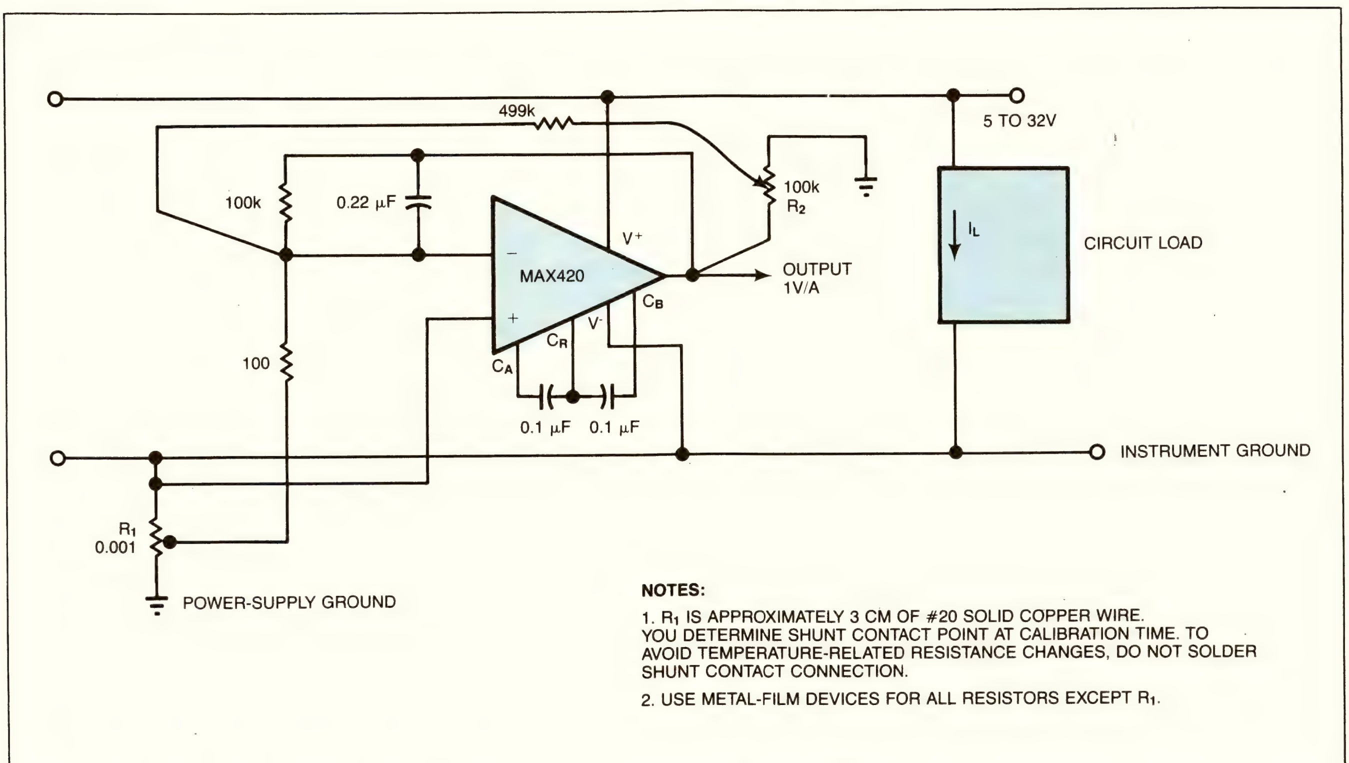


Fig 4—You can make sense measurements *without disturbing the operating load circuitry in this current-sense amplifier circuit because of the low offset specifications of the MAX420 op amp.*

Although temperature obviously contributes to thermoelectric errors, thermal gradients can cause more problems than can the mere presence of heat.

The MAX420 is suitable for this circuit for two reasons: First, because of the MAX420's low offset-voltage specification, you can use a low-value sense resistor (0.001Ω in **Fig 4**). The current measurement will, therefore, have no adverse effects on the operating load circuitry. Second, the MAX420 has a common-mode input range that includes the negative supply, which is circuit ground in this case. When the input range includes ground, the op amp can read the current-sense voltage across R_1 without the need for level shifting. Further, the MAX420 allows the circuit to operate from supply voltages of 5 to 33V.

In **Fig 4,** the sense resistor is actually a short piece of solid copper wire with a movable tap. To calibrate the circuit, you apply a known full-scale current and use the tap as a coarse trim to establish the proper output voltage. You then adjust R_2 to set amplifier gain and develop the precise output-voltage level. If you solder the tap on R_1, be sure to wait until the connection cools completely before you make the fine trim; this way, you'll avoid introducing errors caused by any change in wire resistance at high temperatures.

The circuit in **Fig 4** requires no offset adjustments. With the values shown, the circuit delivers 1V per amp of supply current. You can, however, change the sense-resistor value or the amplifier gain to develop other output ranges. With a 10A supply current, the load will experience a shift in ground potential of only 10 mV, and the sense resistor will dissipate only 0.1W.

You don't need to limit monolithic chopper amplifiers to applications involving low-level signal amplification. Because devices like the MAX420 perform precise amplification, you can use them not only in the primary signal path, but also to stabilize other circuitry. In effect, this approach lets you use CMOS op amps to improve the dc performance of wide-bandwidth or high-power circuitry.

The high-speed 12-bit power D/A converter shown in **Fig 5a** provides a good example of such an application. This circuit uses an LH0101 power op amp (300-kHz power bandwidth and 2A drive capability) as an output stage. The LH0101 has a 15-mV offset-voltage specification, so it can't accommodate 12-bit converter resolution by itself. The MAX421 overcomes the problem by monitoring the LH0101's inverting input and driving the noninverting input so that the summing junction is at 0V (to within 5 μV, the 421's error spec). The result is a high-speed, no-drift DAC circuit.

The MAX421 can use the same power supplies as do the LH0101 and AD565. The voltage divider at the MAX421's output attenuates the LH0101's correction signal to avoid any overdrive problems. Addition of the offset correction has no noticeable effect on the circuit's dynamic performance. **Fig 5b** shows step responses obtained with and without the correction circuitry in operation. The stabilized and unstabilized waveforms exhibit no perceptible slewing or settling-time differences as a result.

Maximize voltage calibrator performance

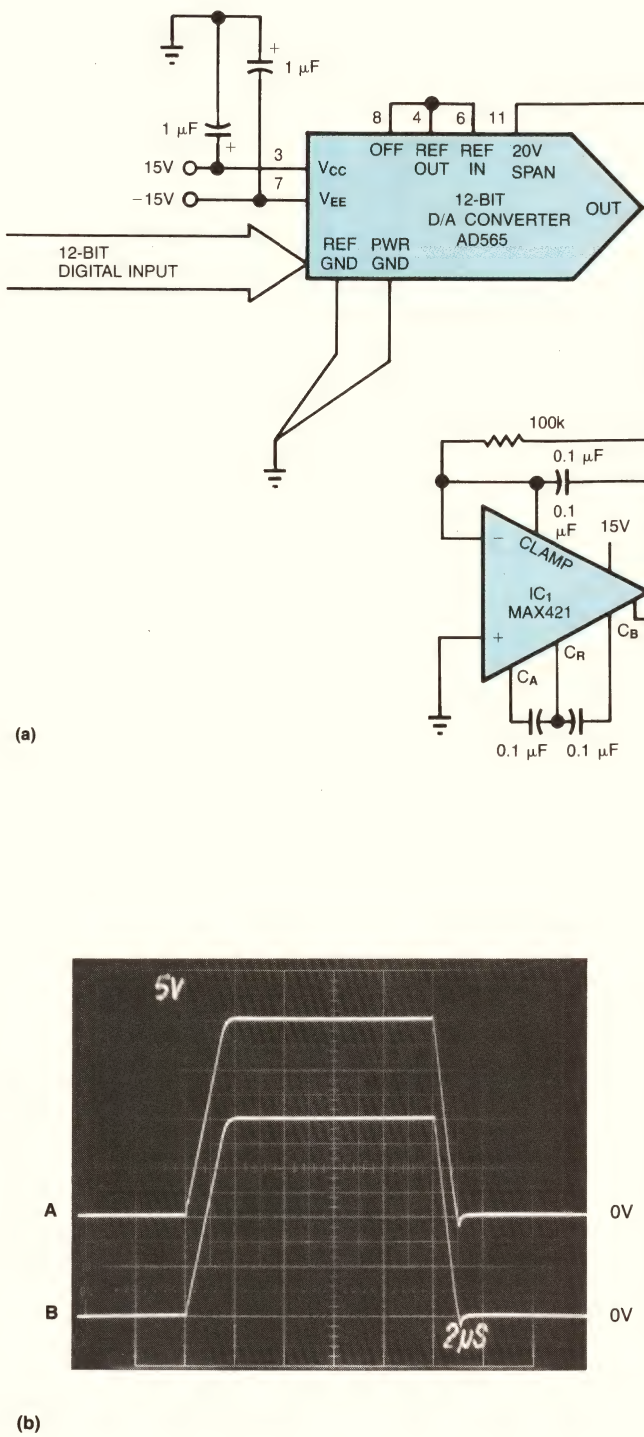
To design a voltage calibrator that can generate a 0 to 10.0000V output with 100-μV resolution **(Fig 6),** you must use an op amp with very good offset, drift, and common-mode rejection specs. Although the circuit is designed for reliable absolute-reference stability, it has a ratiometric capability: Both fixed and variable references, based on the same source, are available simultaneously. Such a feature is especially useful in applications involving linearity checks of digital voltmeters or A/D converters. In such cases, relative rather than absolute results have the most significance. Very few off-the-shelf calibrators, if any, provide this dual-reference feature, so if you want such a feature you must build your own calibrator.

MAX420 amplifiers

MAX420 Series amplifiers offer very low zero-offset and zero-offset-drift specifications (5 μV and 0.05 μV/°C, respectively). The parts can operate over a 5V (or ±2.5V) to 33V (or ±16.5V) supply-voltage range. In addition, input bias current for the op amps specs at only 30 pA.

The amplifiers provide low-power operation at any supply voltage, and they offer FET-type bias currents (30 pA) for high-impedance measurements. The series also includes two devices (MAX422 and MAX423) that draw only 25% of the supply current that the standard parts draw, but that don't sacrifice dc performance. The two parts do, however, exhibit some decrease in bandwidth and output drive capability.

The 8-pin versions of the family are compatible with standard op-amp footprints with respect to inputs, outputs, and supply lines. To enable the amplifiers, you simply connect two external capacitors to the pins that conventional amplifiers normally use for offset trimming.



NOTE:
VERTICAL SCALE IS 5V/DIV;
HORIZONTAL SCALE IS 2 µSEC/DIV.
CORRECTION LOOP IS ON FOR TRACE **A**;
CORRECTION LOOP IS OFF FOR TRACE **B**

Fig 5—Able to satisfy wide-bandwidth or high-power requirements, *this D/A converter circuit* ***(a)*** *employs the MAX421 for offset correction. As the scope photo shows* ***(b)****, the correction scheme has no noticeable effect on the circuit's dynamic performance.*

Monolithic choppers aren't limited to low-level signal-amplification tasks; they can also provide dc stabilization for other circuitry.

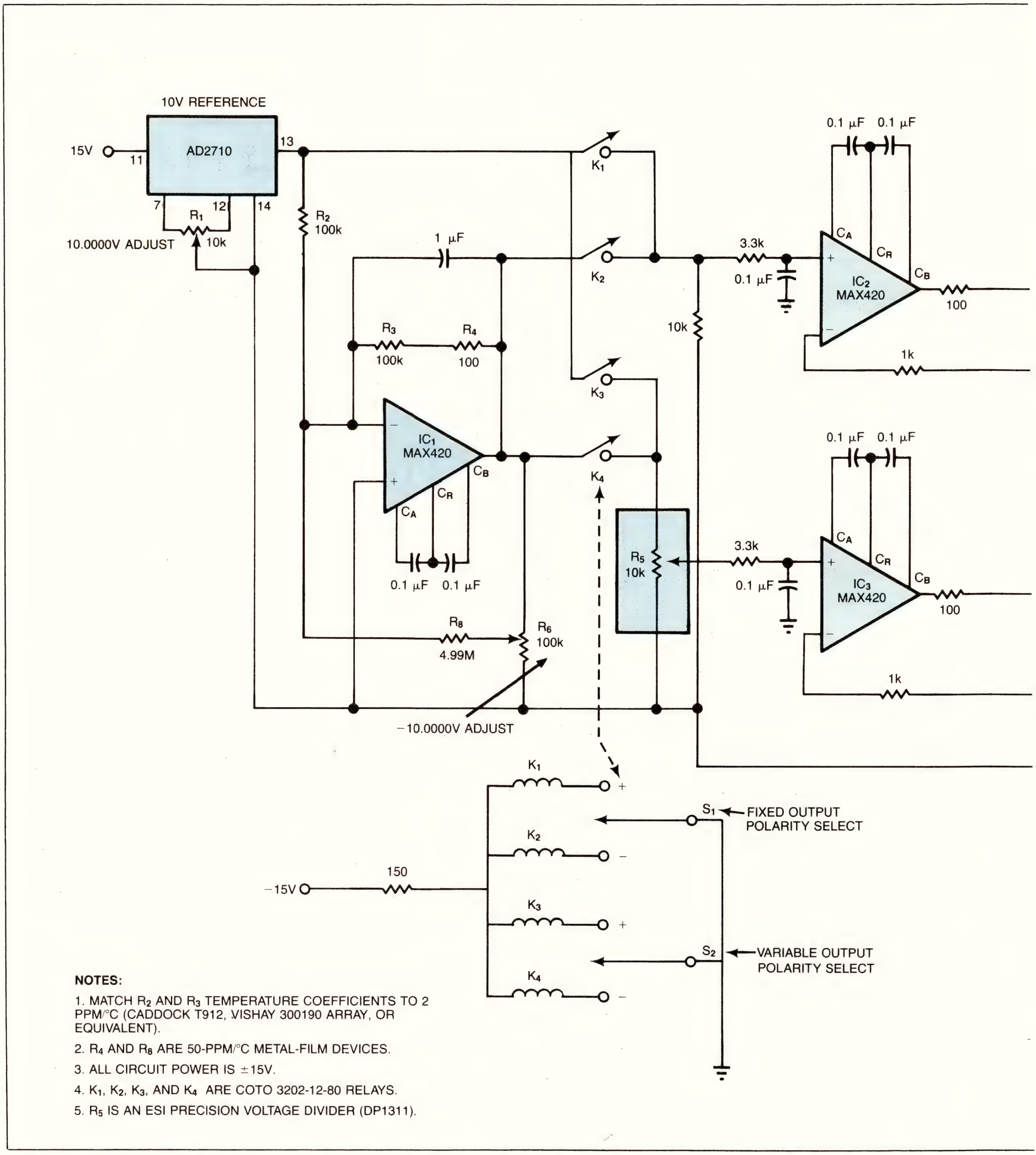


***Fig 6—Because it provides a ratiometric measurement capability,** this voltage-calibrator circuit is useful for checking the linearity of digital voltmeters or A/D converters, two tasks for which relative results are more significant than absolute results.*

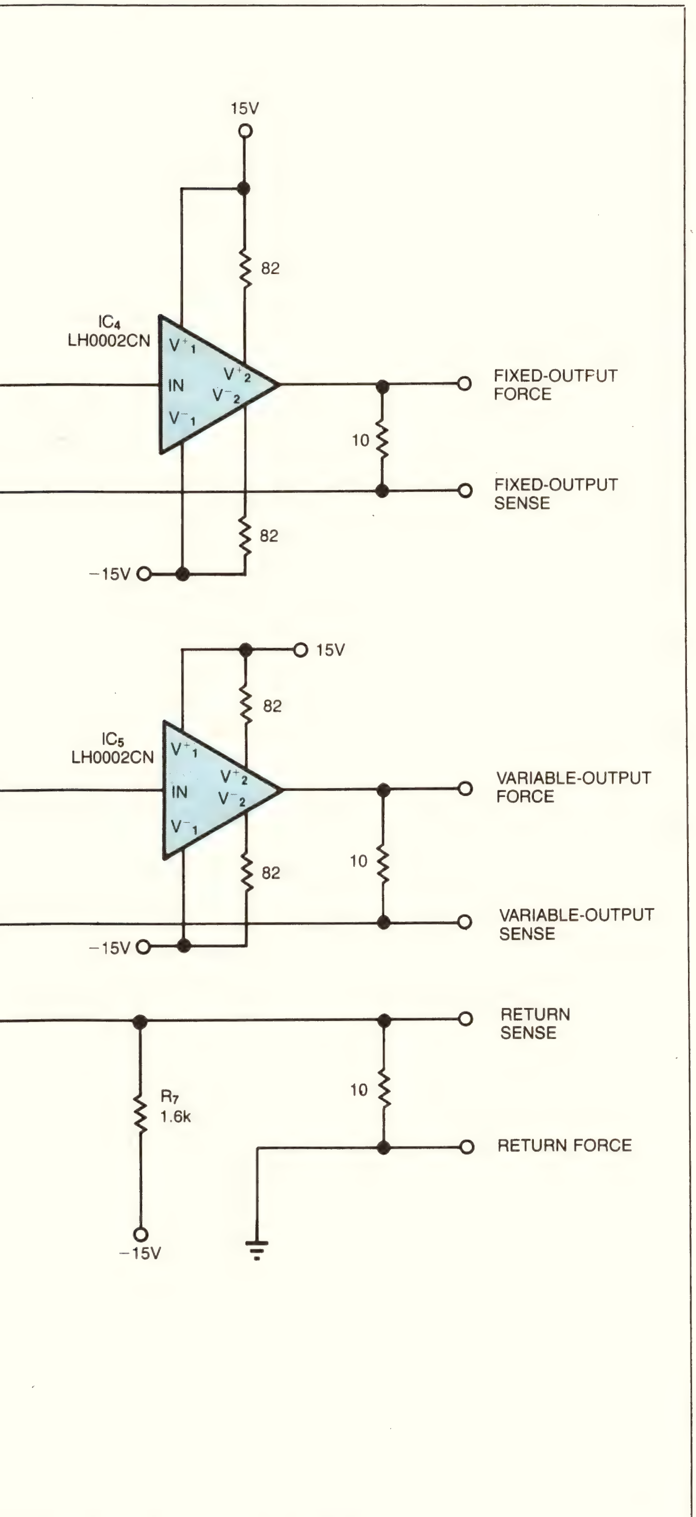


Fig 6's circuit uses an AD2710 voltage reference, which the manufacturer can trim to within 1 mV. If you're going to use the circuit for purely ratiometric measurement, a 1-mV (or even larger) error, and some degree of drift, will cause few problems. For absolute calibration applications, however, you'll require an accurate, low-drift reference. You can adjust the 2710 for a tighter tolerance by using a 10-kΩ multiturn trimmer, as shown in **Fig 6.**

IC_1, an MAX420 connected as a precision unity-gain inverter, provides a negative version of the reference voltage that's adjusted with trimmer R_6. Special reed relays, designed for minimal thermal EMF errors, select either the positive or the negative reference to drive the fixed and variable outputs.

It's not a good idea to use a conventional switch to perform the polarity-select function, because conventional switch contacts generate small thermoelectric voltages. These voltages can introduce significant errors when the output resolution is as low as 100 μV/step, as it is in **Fig 6.** By using four relays, you can select the polarity of the fixed and variable outputs independently.

A Kelvin-Varley voltage divider (R_5), with five decades of adjustment range, divides the fixed reference, developing output increments as small as 100 μV with 20-ppm linearity. The fixed and variable output buffers (IC_2 through IC_5) are composites of MAX420 op amps and LH0101 buffers. This combination provides reasonably good output current drive, and it has less than 10 μV of untrimmed error from offset, common-mode rejection, and other sources. **EDN**

Author's biography

Leonard Sherman is a senior member of the technical applications staff at Maxim Integrated Products (Sunnyvale, CA). In this position, he gets involved in product planning, generates applications literature, and provides customer support. Len has a BSEE degree from Massachusetts Institute of Technology and has been granted one patent. In his spare time, he collects old hi-fi equipment, rates pickles, and watches other people repair automobiles.

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LVDT interface chip's functional blocks offer versatility

The NE5521 chip facilitates the design of position transducer circuits. Moreover, you can configure it for use in multifaceted applications. The signal-conditioning chip comprises building blocks, which provide you with an easy means of forming a variety of other measurement circuits.

Zahid Rahim, *Signetics Corp*

Position transducers used widely in industrial and commercial applications require a great deal of complex signal-conditioning circuitry. The NE5521 signal-conditioning chip, however, puts all but a few passive components necessary for linear-variable differential transformer (LVDT) interface circuits in an 18-pin IC. Although designed specifically for use with LVDT and similar transducers, the chip is also capable of operating as a phase detector, as an ac voltmeter, and as an ac bridge circuit.

In a typical LVDT interface circuit (**Fig 1**), the NE5521 chip's circuits generate the sine-wave excitation signal for the LVDT and demodulate the LVDT's output signal. The demodulator's output signal represents the relative position of the LVDT's moving core. The chip also includes an uncommitted amplifier that can boost or filter the demodulator's output signal and provide gain.

The chip requires a reference

To operate properly, the NE5521 chip requires a stable external reference voltage (V_R) that sets both the common-mode voltage and the rms voltage for the oscillator's output signal. The chip furnishes half of the V_R input voltage as a reference voltage for external circuits. Thus, when you operate the chip with a single power supply, you should reference the circuit's ac signals to the $V_R/2$ reference voltage available at pin 12. However, you should reference the ac signals to ground when operating the NE5521 chip with a positive and a negative power supply. The positive supply voltage, which can be as high as 20V, doesn't require the precise regulation of the reference voltage. Keep in mind that the reference's input voltage can be equal to the chip's highest positive supply voltage, but it mustn't exceed that voltage.

Usually, the NE5521 chip's $V_R/2$ output supplies the reference voltage for the LVDT's secondary coils. Because the secondary coils produce an ac voltage, you must bypass the ac signal to ground at pin 12. Choose a capacitance that provides a low impedance at the excita-

Typical LVDT interface circuits require a stable oscillator.

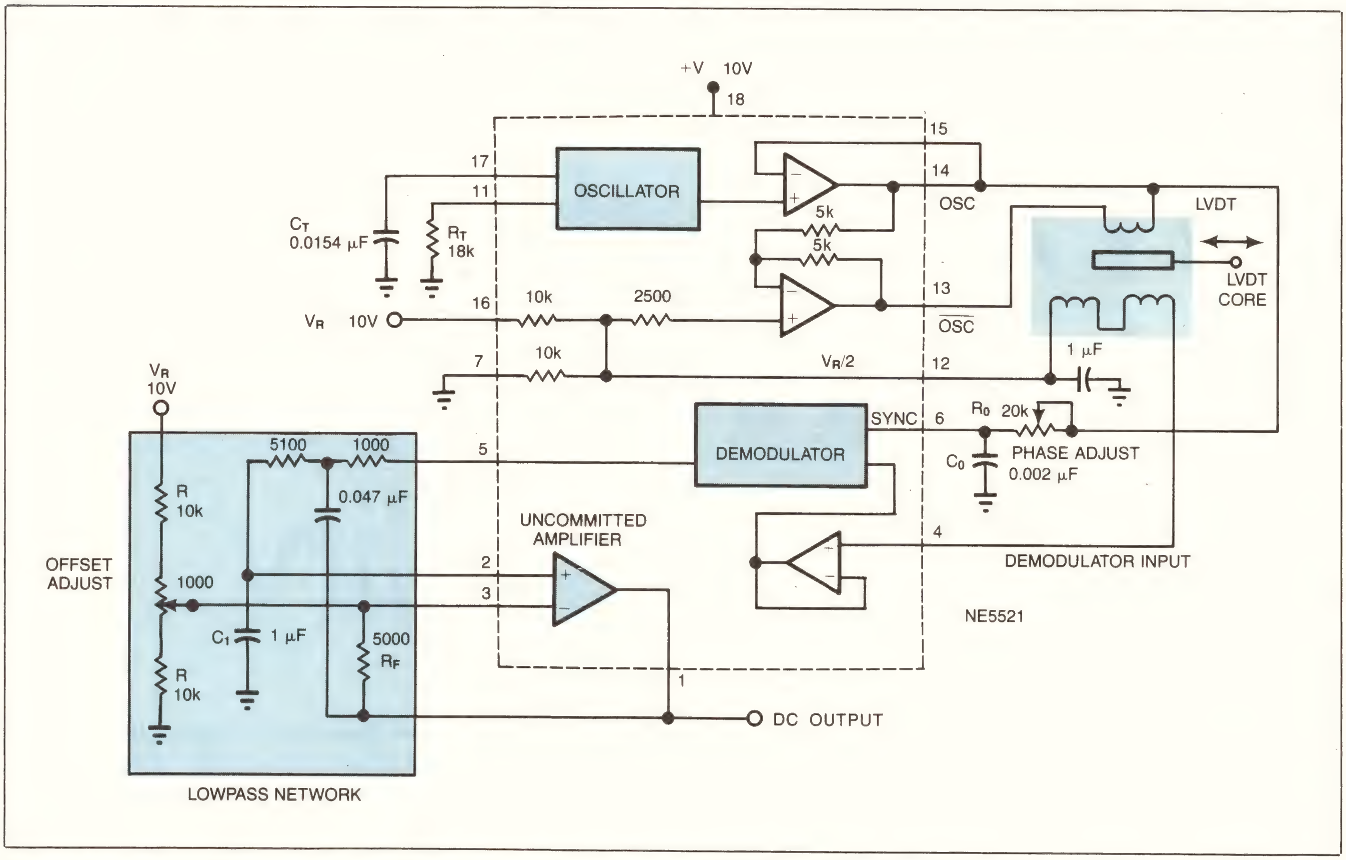


Fig 1—A typical LVDT interface circuit *includes an NE5521 chip, an LVDT transducer, and 13 external components. C_T and R_T set the internal oscillator's frequency, and the remaining resistors and capacitors provide a lowpass network and a phase-adjust circuit.*

tion oscillator's operating frequency; eg, for a 2900-Hz oscillator frequency, use a 1-μF capacitor.

External circuits must not load the chip's $V_R/2$ output because it's a high-impedance voltage source. If loading becomes a problem, ie, if the output varies from the $V_R/2$ voltage, buffer the $V_R/2$ output so it remains stable while providing additional current to your circuit.

Although the NE5521-based LVDT circuit isn't complex, you must pay attention to the circuit's linearity and its null-offset voltage. To minimize the interface circuit's null-offset voltage and to provide optimum linearity, the LVDT's excitation signal and the secondary coils' output signal must be in phase. You have a choice of two ways to match both signals' phases: You can vary the excitation signal's frequency until you find one at which both signals are in phase; or, you can put a variable phase-shift circuit between the oscillator's output and the demodulator's sync input.

The phase-shift circuit in **Fig 1,** which comprises a capacitor (C_0) and a variable resistor (R_0), shifts the oscillator signal's phase before it reaches the demodulator's sync input. Use an oscilloscope to observe the sync-input and the demodulator-input signals as you adjust the 20-kΩ phase-adjust potentiometer for a minimum phase difference. When specifying a 10-kΩ resistance and a 0.002-μF capacitance in the phase-shift network, the phase shift is 20° for a 2900-Hz excitation signal. You can calculate the phase shift from the equation

$$\phi = -\tan^{-1}(\omega R_0 C_0).$$

When the proper phase relationship is set, the demodulator provides a rectified ac signal that relates the LVDT core's position to the signal's amplitude and polarity. To obtain the position as a dc signal, pass the ac signal through a lowpass second-order Butterworth filter built around the chip's uncommitted op amp. You can vary the filter's gain by adjusting its feedback resistor, R_F. The gain varies according to the equation

$$\text{gain} = 1 + R_F/(R/2).$$

The filter's output voltage represents the core's distance from its null position. When the core passes through its center, or null, position, the filter's output switches polarity. However, when the core is in its null position, the dc output may be offset slightly from $V_R/2$ **(Fig 2)**. To compensate for such an offset, move the LVDT core to its null position and adjust the interface circuit's offset-adjust potentiometer until the filter's output provides $V_R/2$.

Besides providing an interface circuit for LVDT transducers, the NE5521 chip also operates with linear phase-differential transformer (LPDT) transducers. To operate an LPDT transducer with an NE5521 chip, however, you need two external op amps that convert

How an LVDT works

A linear-variable differential transformer (LVDT) accurately measures small physical displacements and thus any parameter you can provide as a displacement or as a linear motion. LVDT transducers use one primary and two secondary transformer coils that wrap around a hollow, nonconductive bobbin. A free-moving magnetic core that connects the transducer to the moving equipment slides back and forth within the bobbin **(Fig A)**. When you connect an ac excitation signal to the primary coil, the position of the magnetic core determines how much of the ac signal reaches each secondary coil.

When you connect the two secondary coils so their currents oppose each other, the resulting output voltage varies linearly with the position of the core in the bobbin. At the core's null, or center, position, the differential voltage across the secondary coils is 0V: The voltage in each secondary coil is equal and opposite, thus canceling one another. When the core moves from one side of the null position to the other, the output signal changes phase by 180°. Therefore, the output signal's amplitude indicates how far the core is from its null position, and the signal's phase tells you which side of the null position the core is on.

By synchronously rectifying (demodulating) and then filtering the LVDT's output voltage, you obtain a dc voltage that's proportional to the core's position. Because the output voltage is also directly proportional to the excitation voltage, you must ensure that the excitation signal has a constant amplitude under all operating conditions.

Most LVDT transducers exhibit a small amount of phase shift between the primary coil's input signal and the secondary coils' output signal. The phase shift introduces a dc component in the interface circuit's output that masks the transducer's true null position. You can overcome the dc offset problem by exciting the LVDT at a 0° phase-angle frequency, a frequency at which no phase shift exists between the LVDT's input and output signals. You may find the frequency empirically, observing both signals as you adjust the excitation oscillator's frequency. As an alternative, you can use a circuit that shifts the phase of the secondary coils' output signal until it's in phase with the excitation signal.

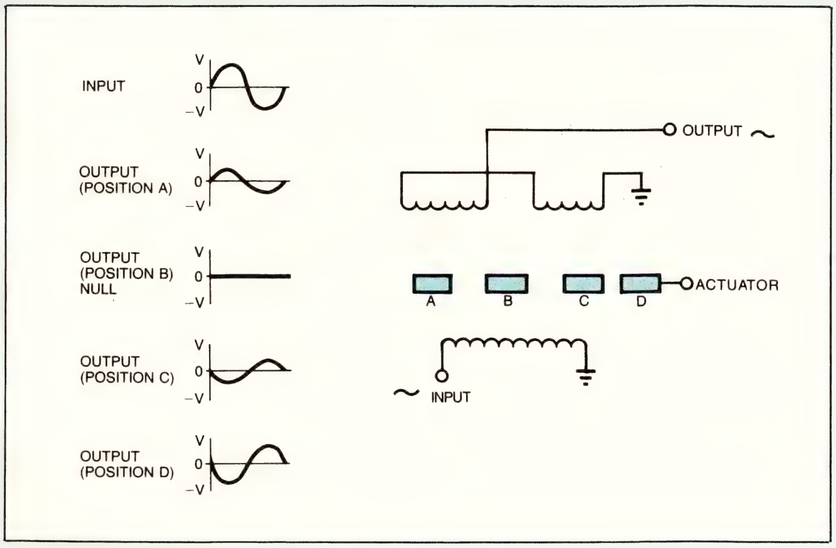


Fig A—An LVDT schematic and sample output waveforms *show how the transducer's output signal varies as the core moves left or right from its null position at B. The output signal changes phase when the core moves through its null position.*

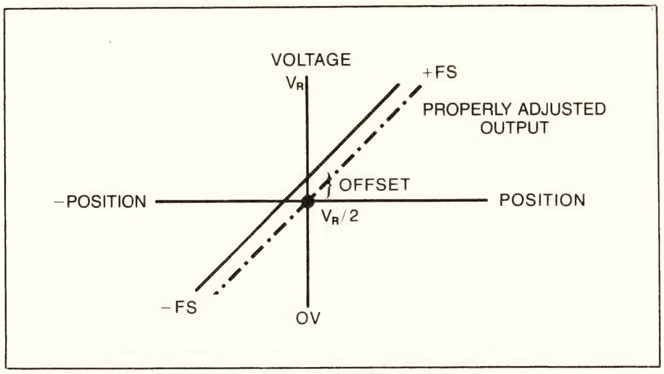


Fig 2—The interface circuit's dc output voltage varies linearly with the LVDT core's position. The output voltage may include an offset that you can adjust to $V_R/2$. When the circuit is properly adjusted, the output changes polarity as the core passes through its null position.

the chip's oscillator signal to the sine and cosine signals that the LPDT requires **(Fig 3)**. Op amp IC_1 provides a lowpass filter circuit that has a 2900-Hz cutoff frequency, the same frequency as the internal oscillator. The filter attenuates the high-frequency components of the oscillator's signal and provides a low-distortion sine wave for the LPDT transducer. The second op amp, IC_2, operates as a 90° phase-shift circuit that supplies the LPDT's cosine signal.

When equal-amplitude and equal-frequency sine and cosine signals each excite a pair of the LPDT's primary coils, the secondary coil picks up a constant-amplitude signal that's the vector sum of the sine and cosine signals. Thus, the secondary coil's signal amplitude remains constant while the signal's phase varies linearly with the core's position.

To provide an accurate cosine signal for the LPDT

A closer look at the NE5521

The NE5521 signal-conditioning chip contains three main circuits: a variable-frequency oscillator, a demodulator, and an uncommitted amplifier **(Fig A)**. The oscillator generates a stable sine wave whose frequency depends on an external capacitor (C_T) and resistor (R_T) as well as on an external reference voltage (V_R). You can calculate the oscillator's frequency from the following equation:

$$f_{OSC}=(V_R-1.3V)/[V_R(R_T+1.5k)C_T].$$

You can also calculate the rms value of the oscillator's output from

$$V_{rms}=V_R/8.8.$$

The oscillator circuit includes two high-gain amplifiers that produce buffered output signals OSC and $\overline{OSC}$; $\overline{OSC}$ is 180° out of phase with OSC. The oscillator exhibits an amplitude drift of less than 50 ppm/°C over −55 to +125°C. THD is less than 2%.

Besides generating the LVDT's excitation signal, the internal oscillator also drives the demodulator's comparator **(Fig B)**, which compares the oscillator's signal with the $V_R/2$ reference voltage. The chip's demodulator extracts phase and position information from an LVDT or LPDT's signal.

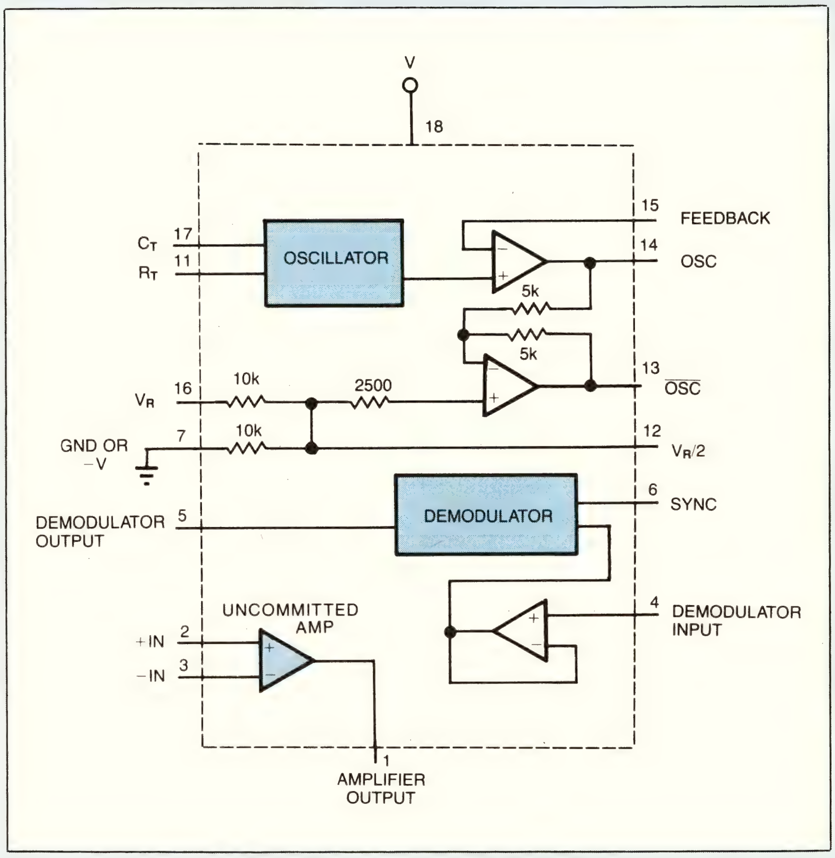


***Fig A—The NE5521 interface chip** contains three main sections: a sine-wave oscillator, a demodulator, and an uncommitted op amp.*

When the proper phase relationship is established, the demodulator circuit provides a precisely rectified position signal.

transducer, you must carefully adjust the circuit's phase-shift network. In the LPDT interface circuit, resistor R_5 and capacitor C_3 determine the phase shift you obtain from op amp IC_2 according to the equation

$$\phi = -2\tan^{-1}(2\pi f_{OSC} R_5 C_3).$$

Thus, to shift the 2900-Hz signal by 90°, you need a 0.01-μF capacitor and a 5.5-kΩ resistor. When you set up the circuit, use a 10-kΩ potentiometer for R_5. Observe the sine and cosine waves on an oscilloscope and then adjust R_5 until the phase difference between the two signals is 90°. When the transformer's core is in its null position, the circuit's dc output will be 0V. When operating the LPDT circuit with split-power supplies, both supply voltages must be well regulated because the sine and cosine signals' common-mode voltage varies as the supply voltages vary.

Demodulator measures phase difference

In addition to operating the NE5521 chip with LVDT or LPDT transducers, you can use the chip's demodulator by itself to measure the phase difference between two equal-frequency signals. As is the case in the LVDT

When the demodulator's sync-input signal is above $V_R/2$, the demodulator inverts the ac input signal. When the sync signal is below the $V_R/2$ voltage, however, the ac signal passes through the follower and to the output. As a result, the demodulator's full-wave rectification occurs in sync with the LVDT's excitation signal. The chip references the demodulator's output to the $V_R/2$ reference voltage.

When the demodulator receives a signal that's 180° out of phase with the sync signal, ie, when an LVDT core passes through its null point, the rectified signal has negative polarity. Thus, the demodulator's output polarity indicates the phase relationship between the sync and the unknown ac signal. In an LVDT circuit, the demodulator's polarity tells you which side of the null point the core is on, whereas the amplitude tells how far from the null point it is.

Because the demodulator operates as a full-wave rectifier, you can filter its output signal to obtain a dc voltage that contains amplitude and polarity information. Several external components configure the NE5521 chip's uncommitted internal op amp into the necessary lowpass filter. Depending on the power supply voltages you choose for the chip, the uncommitted amplifier's output ranges linearly from $-V_{FS}$ for a 0° phase difference to V_{FS} for a 180° phase difference. For a 90° phase difference, the output is 0V. Thus, by accurately calibrating the $\pm V_{FS}$ voltages, you can determine the phase difference between two equal-frequency signals.

At an operating frequency of 1 kHz, the NE5521 offers an offset of less than 2 mV and an offset drift of 5 μV/°C over its 0 to 70°C operating range. Linearity is ±0.05% of full scale.

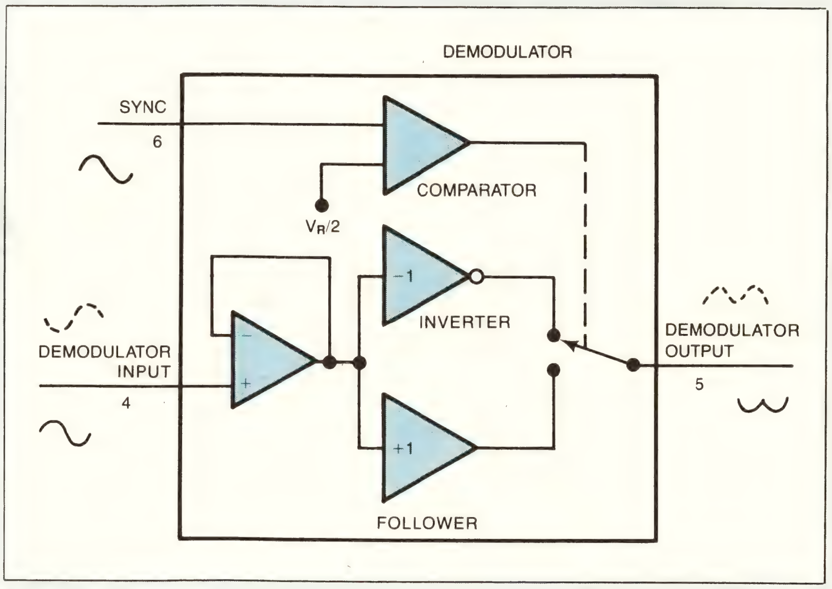


Fig B—The NE5521's demodulator circuit *switches the output line between an inverter and a follower. When you synchronize the comparator's input with the demodulator-input signal, the circuit precisely rectifies the demodulator's input signal.*

An external potentiometer lets you adjust the LVDT circuit's offset at null.

and LPDT interface circuits, the demodulator puts out an ac signal that contains both polarity and amplitude information. By passing the demodulator's output through a lowpass filter, you obtain a dc voltage that represents the phase difference.

Although the phase-difference application doesn't require the NE5521's internal oscillator, the manufacturer recommends supplying an RC network that operates the oscillator at a fixed frequency. If you leave the oscillator's inputs unconnected, active circuits in the chip may saturate, thus degrading the chip's performance.

You can take advantage of the internal oscillator by combining it and the demodulator with several external components to form an impedance-measuring circuit **(Fig 4).** The NE5521 chip's OSC and $\overline{\text{OSC}}$ outputs drive a half-bridge circuit that includes a reference impedance (Z_R) and an unknown impedance (Z_X). Capacitor C_1

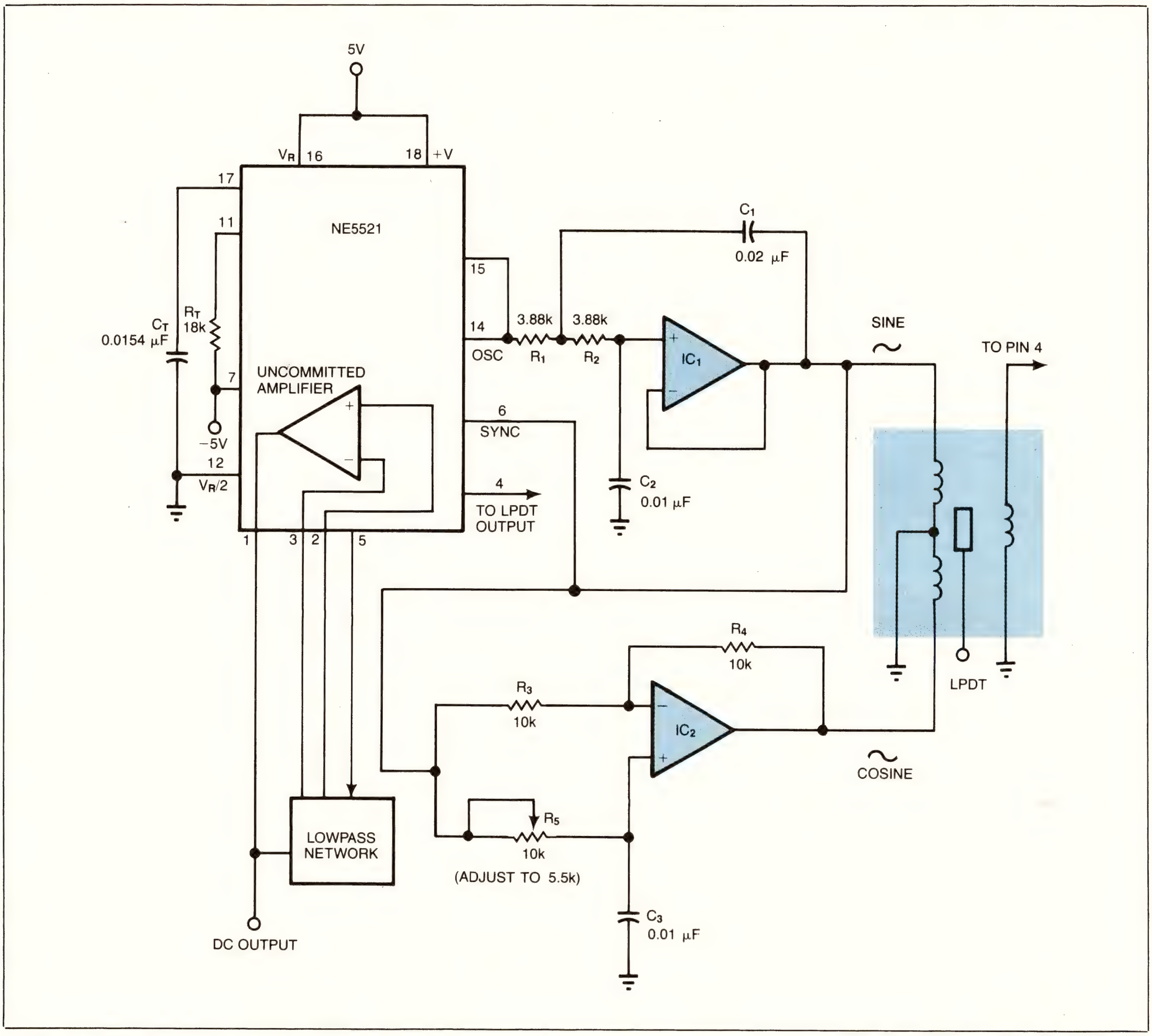


Fig 3—An LPDT interface circuit *includes two op amps that provide precise sine and cosine signals to the transducer's coils. The LPDT puts out a constant-amplitude signal that changes its phase as you move the core. The circuit's dc output accurately corresponds to the core's position.*

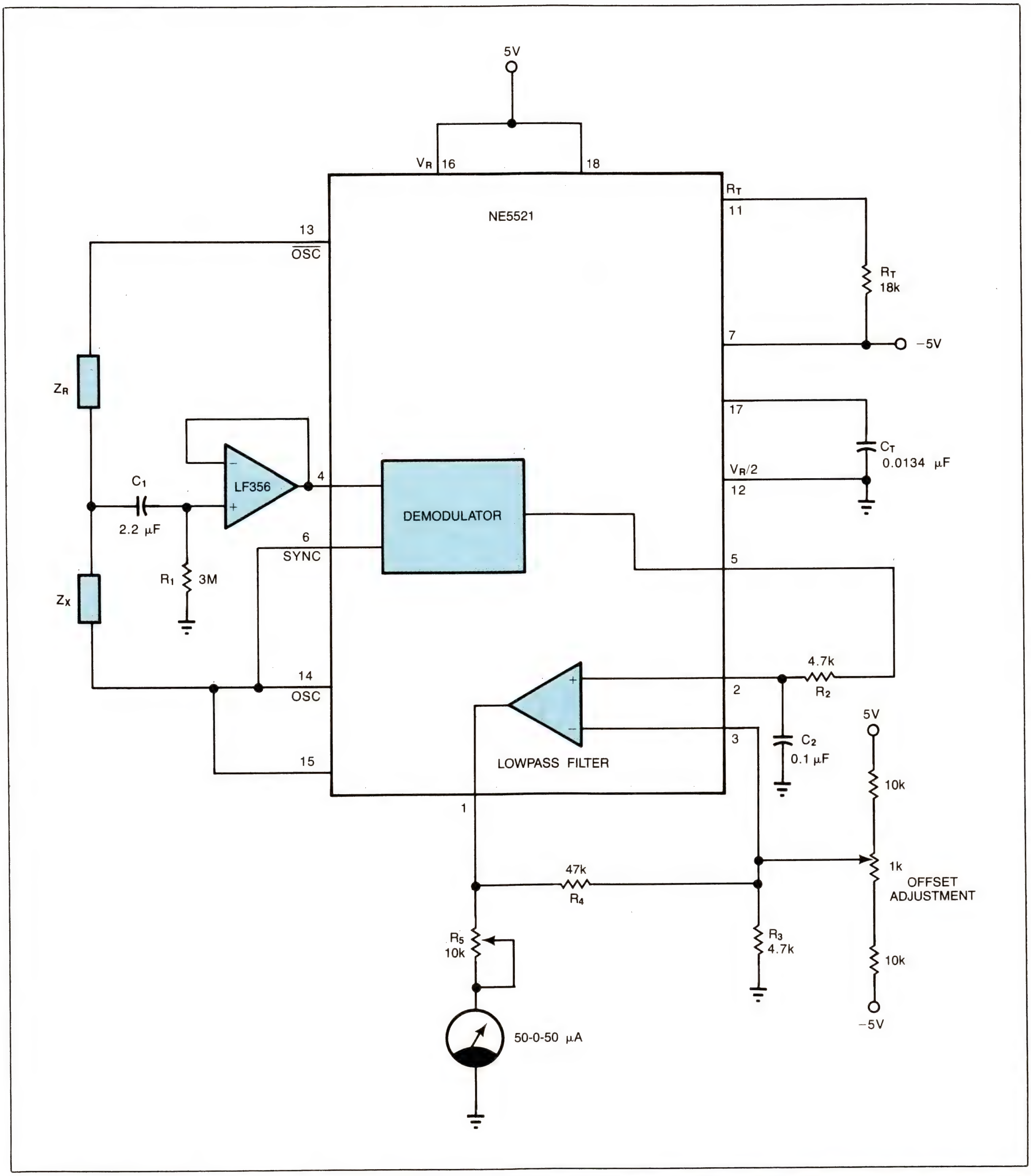


Fig 4—An ac half-bridge circuit *uses the NE5521's internal oscillator to drive two components Z_X and Z_R with out-of-phase sine waves. The lowpass filter provides a voltage that indicates the relative mismatch between the components' impedances.*

Combine the oscillator, demodulator, and filter and measure unknown impedances with an accuracy of 0.05%.

passes the ac signals from the half-bridge circuit to an LF356 op amp, which in turn drives the demodulator's input. Resistor R_1 biases the op amp's output at 0V when no ac signal arises from the bridge circuit. Because it has a typical input bias current of only 30 pA, the LF356 ensures that there is negligible dc offset from the bias current flowing through the 3-MΩ resistor.

Before you use the ac-bridge circuit, first connect it to two components (Z_R and Z_X) with impedances that match within 0.01%. Next, adjust the offset-adjustment potentiometer until the voltage at the amplifier's output (pin 1) is 0V. Use the 10-kΩ potentiometer in series with the microammeter to limit current through the meter to ±50 μA so the meter doesn't go off scale for the impedance range you're measuring. You can calibrate the meter by supplying a known reference impedance for Z_R and noting microammeter deviations as you substitute other known impedances for Z_X. The circuit measures unknown impedances with an accuracy of at least 0.05%.

In such a circuit, the demodulator and the filter circuits operate as described earlier for the LVDT circuit. Thus, the ac half-bridge circuit provides a dc output voltage that's proportional to the mismatch between the reference impedance Z_R and the unknown

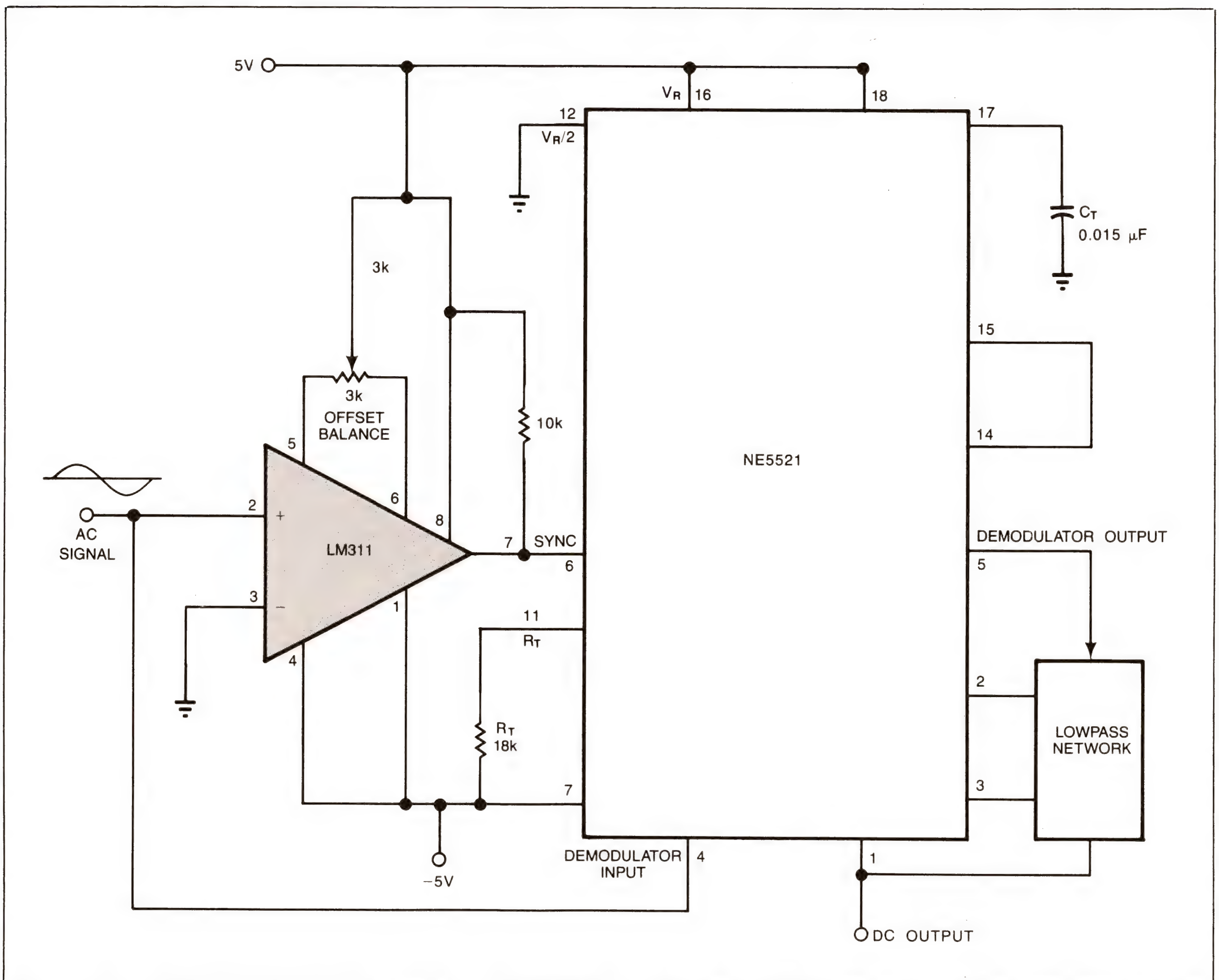
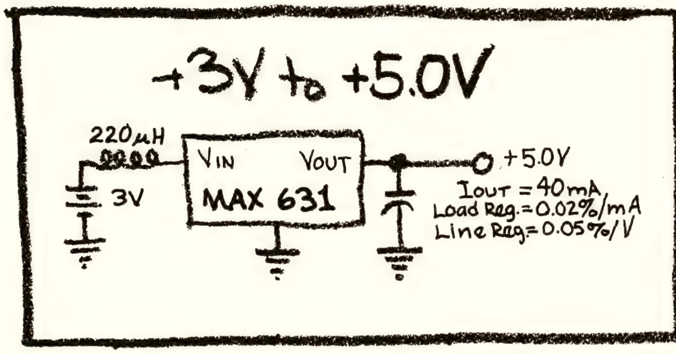
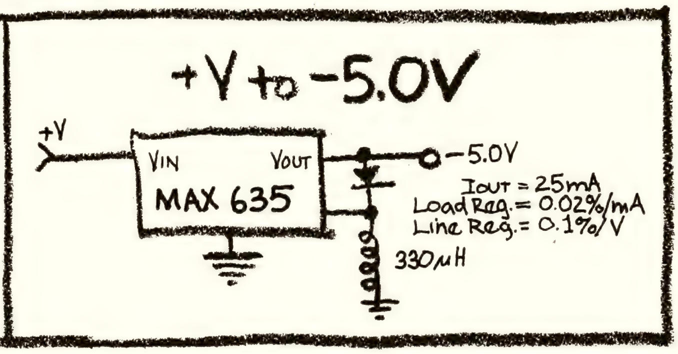


Fig 5—You can measure a signal's rms voltage *by precisely rectifying the unknown signal with the NE5521 chip's demodulator. The LM311 comparator provides the demodulator with an in-phase reference signal.*

ANY VOLTAGE IN. ANY VOLTAGE OUT.





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Maxim DC-DC Converters

DEVICE	INPUT VOLTAGE	OUTPUT VOLTAGE	COMMENTS	PRICE (100 up)
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MAX631	2.0V to 5.6V	+5V	Only 2 external components	$3.50
MAX632	2.0V to 12.6V	+12V	Only 2 external components	$3.50
MAX633	2.0V to 15.6V	+15V	Only 2 external components	$3.50
MAX641	2.0V to 5.6V	+5V	10 Watts w/external MOSFET	$3.72
MAX642	2.0V to 12.6V	+12V	10 Watts w/external MOSFET	$3.72
MAX643	2.0V to 15.6V	+15V	10 Watts w/external MOSFET	$3.72
MAX4193	2.4V to 16.5V	Vout > Vin	Programmable output	$2.15
INVERTING CONVERTERS				
MAX634	3.0V to 16.5V	up to −20V	Programmable O/P, precision ref.	$2.90
MAX635	3.0V to 16.5V	−5V	Only 3 external components	$3.50
MAX636	3.0V to 16.5V	−12V	Only 3 external components	$3.50
MAX637	3.0V to 16.5V	−15V	Only 3 external components	$3.50
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Whatever an annal is.

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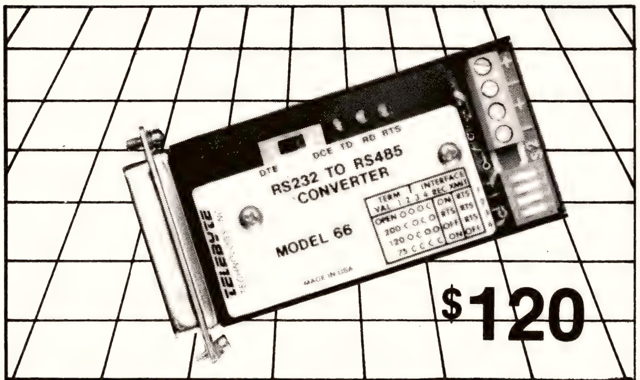

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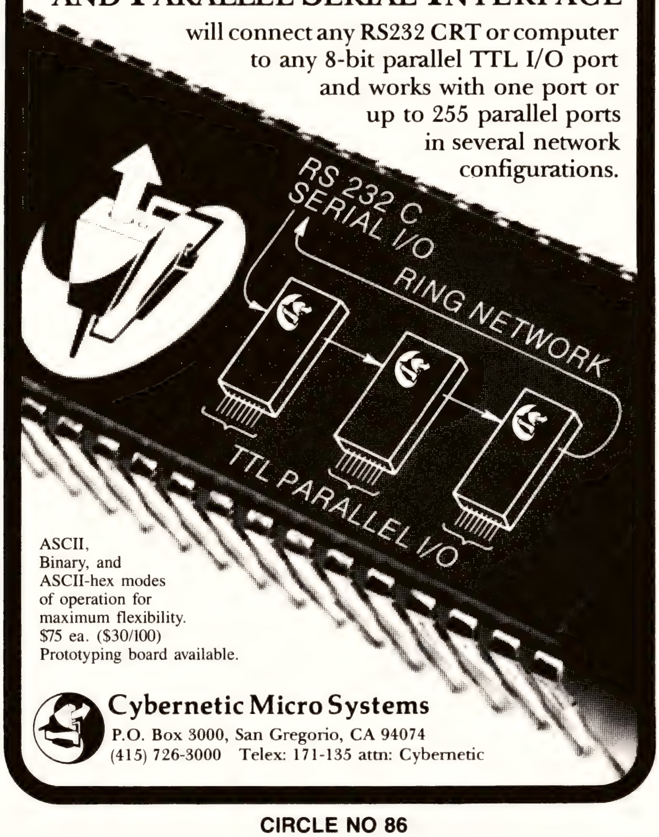

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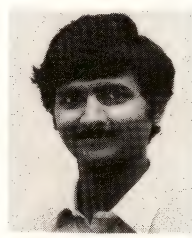
impedance Z_X. The dc signal's polarity indicates whether Z_X is greater than or less than Z_R.

You can also use the NE5521 chip in a circuit that accurately measures an ac signal's rms voltage. Although you could connect an unknown ac signal to the demodulator, filter the demodulator's output, and then measure the filter's output voltage, keep in mind that the demodulator operates synchronously with the internal oscillator. Thus, you need to adjust the oscillator to accurately match the frequency of each unknown signal you want to measure.

To keep the circuit and its operations simple, derive the demodulator's sync signal from the ac signal itself. An LM311 comparator configured as a zero-crossing detector generates the necessary sync signal from the unknown ac signal **(Fig 5)**. The LM311 delivers a square wave that's in phase with the ac signal you're measuring.

After supplying the chip with the in-phase sync signal and an unknown ac signal, the demodulator accurately rectifies the ac signal. The chip's auxiliary amplifier operates in a typical filter circuit that accepts the demodulator's output and provides a dc voltage that's proportional to the ac signal's rms value. The rms-voltmeter circuit provides an accuracy of better than 0.05%. **EDN**

Author's biography



Zahid Rahim works for Signetics Corp's Linear LSI Div (Sunnyvale, CA), where he designs data-conversion and data-acquisition ICs. Prior to joining Signetics, he earned an MSEE from Columbia University and a BA in math and physics from Wartburg College, Waverly, Iowa. Zahid is a member of the IEEE and Kappa Mu Epsilon and enjoys coin collecting and playing tennis.

References

1. Herceg, Edward, *Handbook of Measurement and Control*, Schaevitz Engineering, Pennsauken, NJ.
2. Yeaple, Frank, "Linear position transducer changes phase instead of amplitude," *Design News*, November 5, 1984, pg 180.

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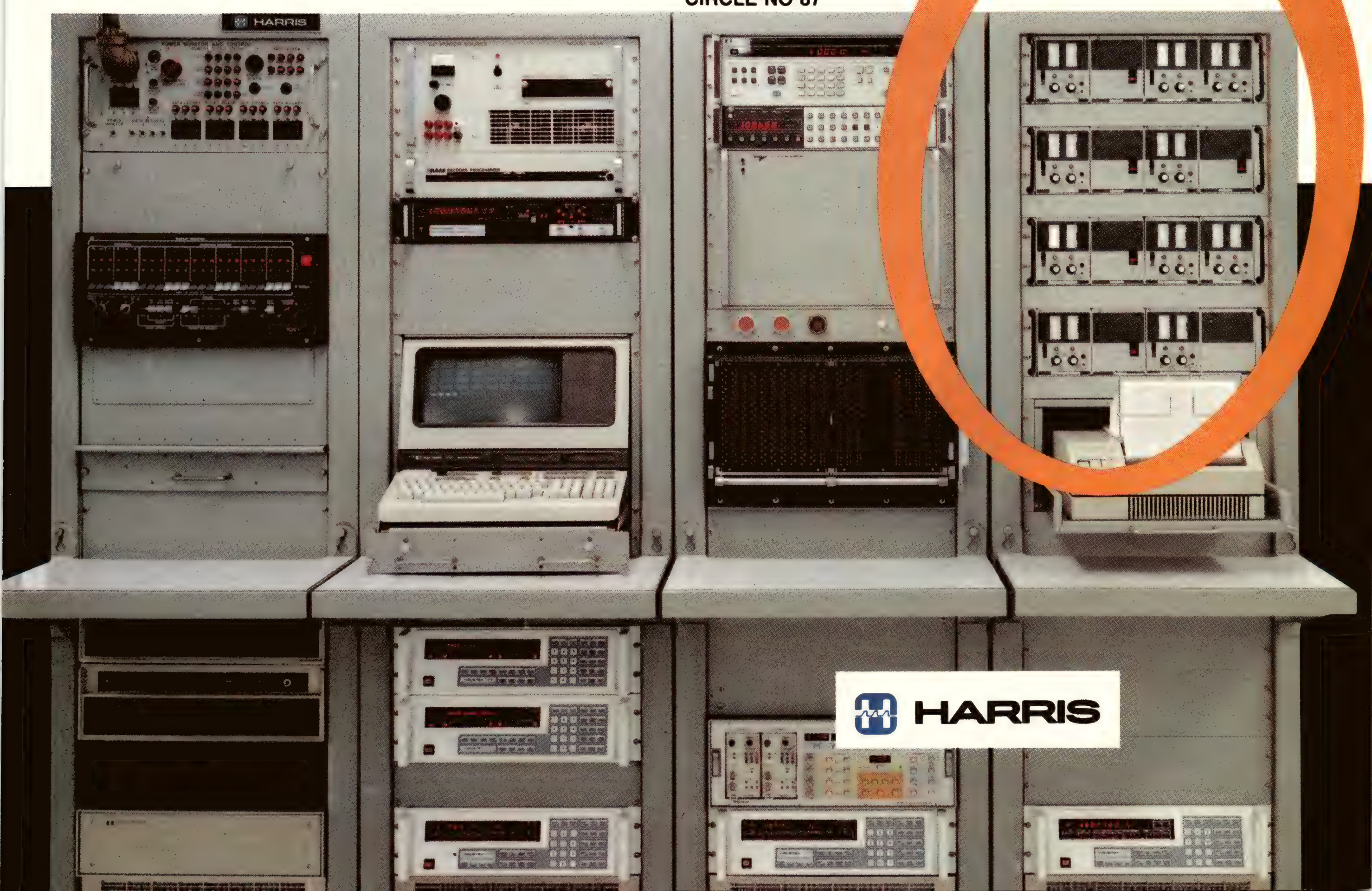

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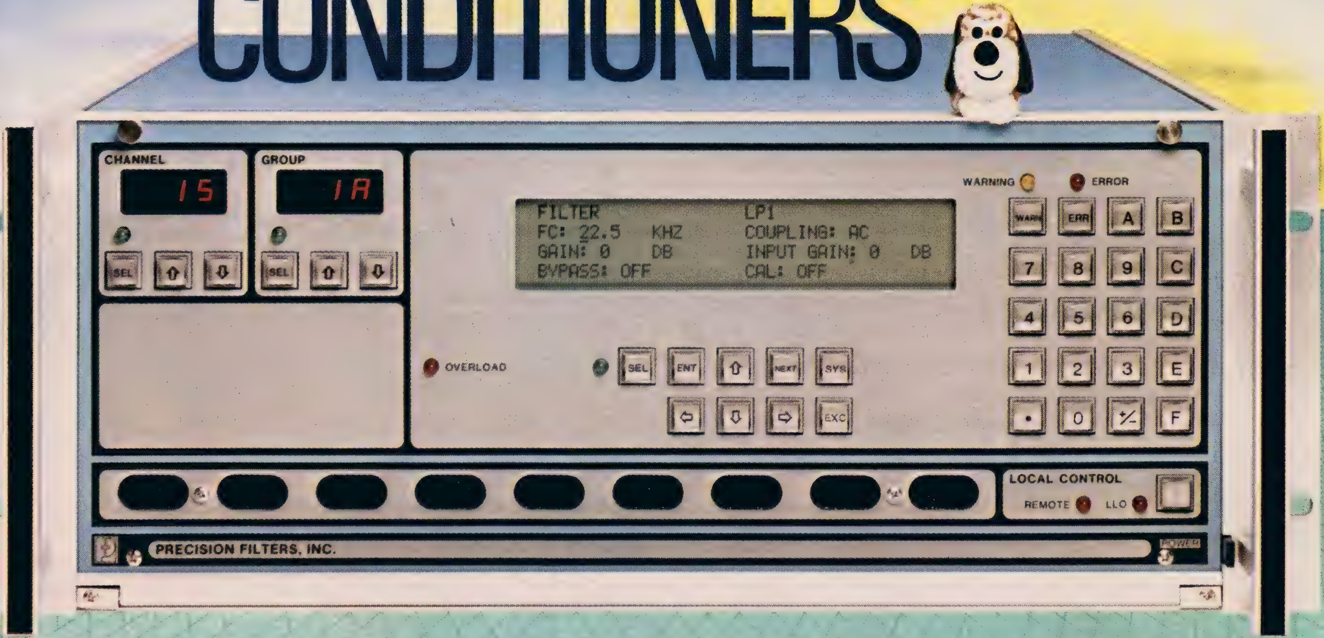

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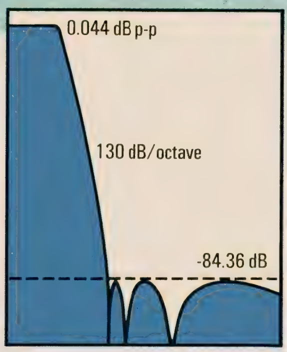

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Digital gain control streamlines signal-acquisition systems

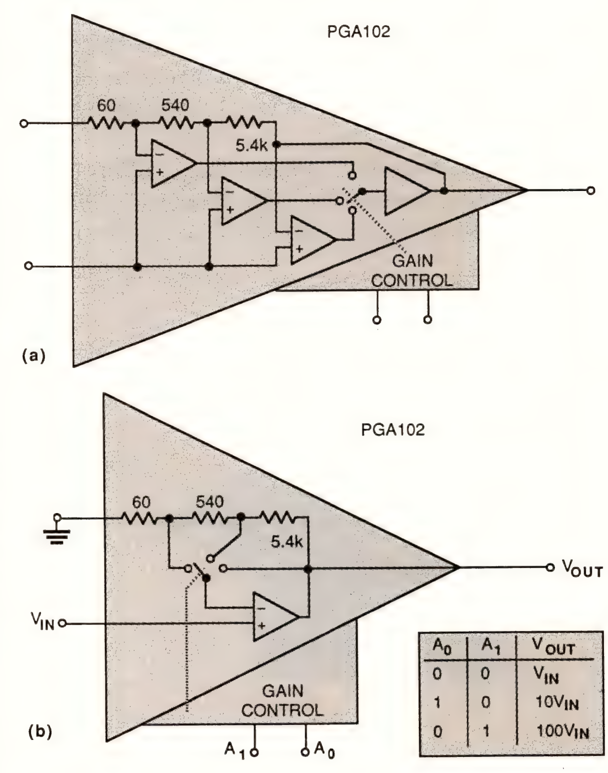
A monolithic op amp that includes digital gain control simplifies the design and layout of a signal-acquisition system. By adding some simple circuitry to the op amp, you can combine the part's digital-gain-control function with such functions as automatic gain control and current-feedback amplification.

Jerald Graeme, *Burr-Brown Corp*

By adding some simple circuitry to a monolithic programmable gain amplifier (PGA), you can design circuits that combine the PGA's digital gain control with gain-polarity control, automatic gain control, current-feedback amplification, or a sample/hold function or V/F converter.

The monolithic PGA102 op amp **(Fig 1a)** offers programmable gains of 1, 10, and 100. It includes three input stages with a user-accessible differential input for each; however, only the selected stage closes a feedback loop, so the selected stage's tap in the feedback network determines the operating gain.

The op amp's three input stages sense different taps on a feedback network, and a gain-control circuit activates one of the three by connecting it to the input



A_0	A_1	V_{OUT}
0	0	V_{IN}
1	0	$10V_{IN}$
0	1	$100V_{IN}$

Fig 1—The PGA102 includes three switched input stages *and one output stage* ***(a)****. For most purposes, the circuit can be represented as a switched-gain noninverting amplifier* ***(b)****.*

To provide digital control of a signal's polarity as well as its gain, add a switched op-amp stage to the PGA102 op amp.

biasing current source (the other two input stages remain off). The only input stage that determines operating gain is the selected input stage, and it does so by closing the feedback loop. Because it switches the input stages instead of the feedback connections, the op amp can use switched-current circuitry.

Switched-feedback equivalent

To understand how the PGA102 operates, consider the simplified, symbolic representation of the op amp in **Fig 1b.** In the figure, a 2-bit digital-control code switches the noninverting amplifier's gain to 1, 10, or 100. The three gain levels offer 0.05% (or better) accuracy; switching between them requires no more than 8 μsec for 0.01% settling. Furthermore, the amplifier's bandwidth is at least 250 kHz at any gain level.

The switched-gain, noninverting amplifier in **Fig 1b** differs from the actual configuration of the PGA102, however, in that the figure doesn't show any dependence of the offset voltage on the gain range. In the actual PGA102 circuit, each gain range uses a separate input stage with its own offset voltage, so the offset will usually change when the gain changes. You should keep this behavior in mind when you use the simplified switched-feedback model **(Fig 1b)** to represent the PGA102.

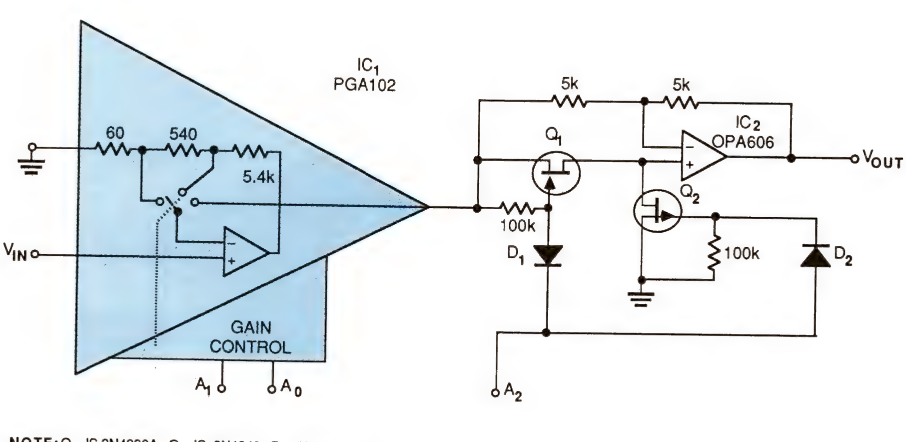
By adding a switched op-amp stage **(Ref 1)** to the PGA102, you can provide digital control of a signal's polarity as well as its gain **(Fig 2)**. The third control bit, A_2, allows you to insert a gain of $+1$ or -1 in the signal path. Such a circuit would be useful, for instance, in a system in which the amp drives an A/D converter, because A/D converters handle unipolar signals more accurately than they handle bipolar signals.

The logic level of control bit A_2 configures IC_2 as either a voltage follower or as a unity-gain inverter. For example, a high level at A_2 applies forward bias to diode D_2 and pinches off FET Q_2, but applies reverse bias to diode D_1, allowing FET Q_1 to remain on. Under these conditions, the op amp (IC_2) behaves as a voltage follower and tracks the PGA102's output voltage.

Configure op amp as follower or inverter

On the other hand, a low level at A_2 reverses the states of the two diodes and their associated FET switches, producing a unity-gain inverting amplifier. Note that A_2 must drive the FET switches to their pinch-off levels, even in the presence of a large output from IC_1; an output of $\pm 10V$, for instance, requires that the control signal have a $\pm 12.5V$ range.

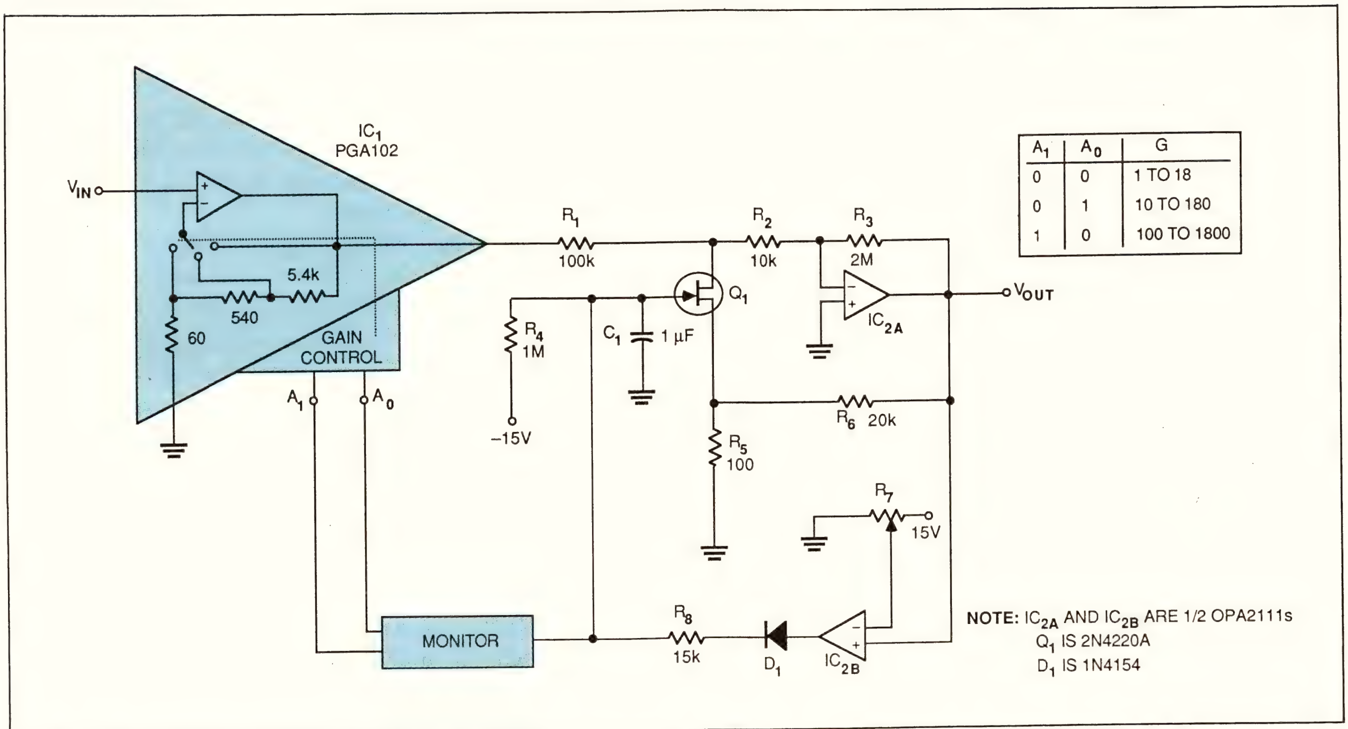
This application uses JFETs because they provide make-before-break switching (JFETs are depletion-mode devices, which remain on until they're driven off). Both switches are on for a brief interval when A_2 makes a transition from one state to the other. The switches' closure would appear to short the PGA102's output to ground through the two JFETs in series. The JFETs have inherent current limits, which prevent



A_2	A_1	A_0	V_{OUT}/V_{IN}
0	0	0	−1
0	0	1	−10
0	1	0	−100
1	0	0	1
1	0	1	10
1	1	0	100

NOTE: Q_1 IS 2N4220A; Q_1 IS 2N4342; D_2 AND D_2 ARE 1N4154s.

Fig 2—By switching an op amp between voltage-follower and inverting-gain modes, *you can digitally control both the polarity and the magnitude of gain.*



A_1	A_0	G
0	0	1 TO 18
0	1	10 TO 180
1	0	100 TO 1800

Fig 3—This automatic gain-control circuit *maintains V_{OUT} at a set peak level for input signals having an 1800:1 dynamic range. The monitor circuit is equivalent to a 2-bit A/D converter that sets the PGA's prescale gain.*

shorting, however: The maximum current drain is limited to the lower I_{DSS} value offered by the two JFETs.

During an A_2 logic transition from 1 to 0, the gain of op amp IC_2 drops from +1 to near zero (when both FETs are on) and then to −1. This action eliminates output transients because one of the two FET switches is always on, providing a low-impedance path for the discharge of switch capacitance during A_2's state changes. Although you could also use enhancement-mode MOSFETs, such break-before-make devices don't provide a quick-discharge path, so they can permit transients as high as 1.2V during a 30-nsec switching interval.

Adding the gain-polarity control doesn't have a significant effect on accuracy as long as you use an OPA606 op amp or equivalent and make two circuit adjustments. First, you can reduce the offset voltage by using the op amp's offset-adjust terminals (in any case, the op amp's input offset voltage is divided by the PGA102's gain). Next, you adjust the op amp's 5-kΩ resistor values for 0.05% (or better) matching, which will provide at least 0.1% overall dc accuracy for input signals in the 100-mV to 10V range.

The OPA606's fast settling time and large bandwidth preserve ac response: The output settles to 0.01% in 2.1 µsec for either a signal transition or a polarity-change command. For high gain, however, the PGA102's settling time (8 µsec) is the limiting factor in **Fig 2**'s circuit. Similarly, because the OPA606's bandwidth is so wide (13 MHz), it doesn't affect the bandwidth of the circuit, which is limited by the PGA102 to 250 kHz at a gain of 100.

Add automatic gain control

To add automatic gain control (AGC) to the digital-gain-control functions of the PGA, you can use the circuit in **Fig 3 (Ref 2)**. Unlike many implementations of automatic gain control, this circuit can accept a wide range (more than 1800:1) of signal amplitudes. In response to signal peaks detected by IC_{2B}, FET Q_1 provides basic gain control by varying the gain of inverting amplifier IC_{2A}. The peaks detected by IC_{2B} develop the FET's control voltage on holding capacitor C_1. A monitor circuit (equivalent to a 2-bit A/D converter that's accurate to at least 10%) senses that voltage in order to detect any need for a change in the PGA102's gain.

Another way to provide digital control of current gain is to configure the PGA as a current amplifier.

FET Q_1 serves as a voltage-controlled resistor, thereby providing the continuously variable portion of gain control. In conjunction with R_1 and R_2, the FET acts as the grounded leg of a tee network that reduces modulation of the FET's on-resistance and the consequent distortion. Further, feedback via R_5 and R_6 drives the FET's source to reduce overall distortion to 0.07%.

By controlling the variation of FET resistance, you control the tee network's range of equivalent resistance and, therefore, you control the range of gain for the basic AGC circuit. When the FET is turned off, IC_{2A}'s equivalent input resistor is 110 kΩ, so IC_{2A}'s gain is −18.2. On the other hand, when the FET is fully on and has a drain-source resistance no greater than 1 kΩ, this resistance is halved by the effect of feedback from R_5 and R_6, and the signal swing across the FET is doubled. Consequently, the tee network looks like a 2-MΩ resistor, and the op amp's gain is −1. The add-on output stage has a maximum gain range of 18.2:1 and the PGA's maximum gain range is 100:1, so the overall range is 1820:1.

Adjust response time

Voltage on C_1, the AGC holding capacitor, controls the FET and the PGA. That voltage is controlled, in turn, by feedback from IC_{2B}, which operates as a comparator. The comparator responds to the difference between the signal peaks and a reference level set by potentiometer R_7. If that reference level is lower than the positive-going output peaks, the comparator output swings positive, applying forward bias to diode D_1 and increasing the voltage on C_1. The resulting drop in the FET's drain-source resistance shunts more signal current to ground.

R_8 and C_1 determine the response time for this action. If the output signal remains too low to trigger the comparator, the discharge of C_1 through R_4 will reduce the FET bias and the consequent signal-shunting effect until the increasing gain allows triggering to occur again. You should set C_1's voltage-decay rate low enough to prevent overshoot during gain changes. On the other hand, you should set the rate high enough for the circuit to respond to sudden drops in signal level, but not so high as to introduce distortion by allowing too much change in gain between signal peaks. The component values shown provide a 15-msec response-time constant and a 1-sec decay-time constant, allowing the circuit to respond to frequencies as low as 10 Hz.

FET Q_1 goes from pinch-off to full conduction as the C_1 voltage ranges from −2.5V to 0V. An attempt by the circuit to adjust this voltage below −2.5V (ie, beyond the point of complete shut-off) would indicate that the AGC can't provide enough gain, so the monitor circuit would increase the PGA102's gain. At the other extreme, a positive voltage on the capacitor indicates that the circuit can't shunt enough signal, so the monitor reduces the PGA102's gain.

Another way to provide digital control of current gain is to configure the PGA102 as a current amplifier **(Ref 3).** You modify the feedback network by adding a sense resistor R_1 and a gain-setting resistor R_2 to the PGA102 **(Fig 4a).** This combination causes the amplifier and its feedback circuit to float on the load voltage. The input current (I_{IN}) develops a voltage on R_1 that drives the PGA input independently of signal current in the load resistor.

Load current has three sources

The load current (I_{OUT}) is the sum of I_{IN}, the current from the PGA's internal feedback network, and the current from R_2 (an amplified replica of I_{IN}). The circuit's transfer function is a linear relationship between the input and output currents with a gain value that's established by the PGA102's gain setting. For the resistor values shown in **Fig 4a,** the relationship is simply $I_{OUT}=(1+10G)I_{IN}$, where G is the PGA102's gain.

You choose the resistor values for R_1 and R_2 by making a compromise between the need for dc accuracy and several other (conflicting) requirements. For example, for the PGA to receive an input signal that's large compared to its input offset voltage, R_1 should be large. A large input signal, however, is inimical to output-voltage compliance, gain accuracy, and the avoidance of slew-rate limiting. Because the R_1 voltage floats between the signal source and load, this voltage reduces the range of output swing or compliance. Also, the PGA's output swing must, of course, remain within the constraints imposed by the power-supply and load voltages, and the output frequency must not exceed the value imposed by slew-rate limiting.

Choose low-value external resistors

Because of the absolute tolerance of the PGA102's internal feedback resistors, you'd do well to choose low values for the external resistors. Although the internal ratios are closely trimmed for gain accuracy, their absolute values may vary ±20%. A small R_2 will minimize the effect of this variation. Further, because R_2 is in parallel with the total 6 kΩ of feedback resistance, a small value for R_2 has little effect on the

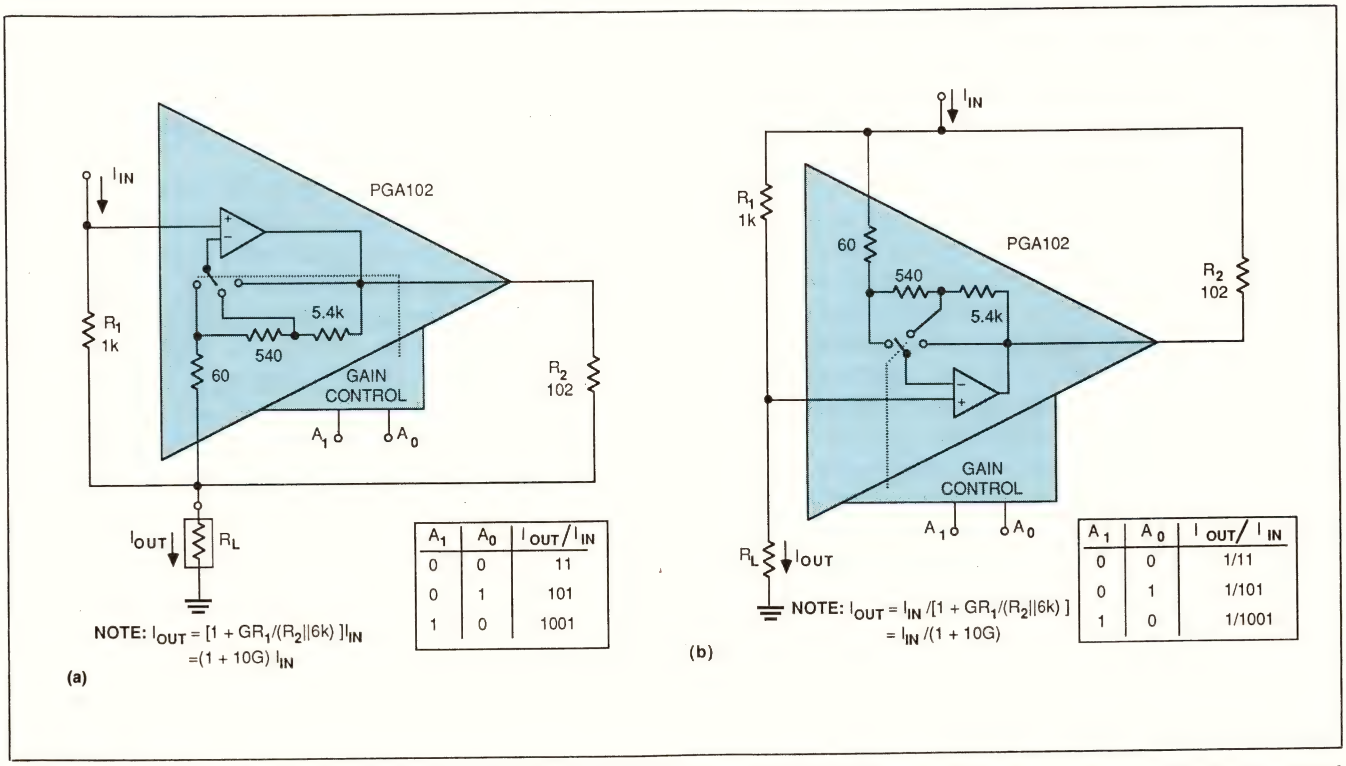


Fig 4—You can achieve digital control *of current amplification* ***(a)*** *or attenuation* ***(b)*** *by connecting an external current-feedback network around the PGA.*

feedback network. You can omit R_2, however, as long as you can accept a 20% tolerance on the output voltage. If you omit R_2, load current will be limited to 1.5 mA.

With the R_1 and R_2 values shown, the circuit in **Fig 4a** can accurately accommodate a 200:1 range of input current. The high end of this range is limited by the PGA102's 5-mA output-current rating. The low end of the range is limited by the combined effect of its input bias currents and input offset voltage. Input bias current contributes no more than a 50-nA error to the input current; the high-gain offset voltage (200 μV) translates to as much as 200 nA of error, based on the 1 kΩ value shown for R_1. When you combine these errors, you can see that the circuit can handle input currents as low as 25 μA with no more than 1% of offset error. Further, the voltage dropped across the selected resistors reduces the output-voltage compliance by only 0.5V.

Circuit translates impedances

The low signal amplitude across the PGA also enables the PGA to realize its full 250-kHz bandwidth without slew-rate limiting. In addition, the low resistance in R_2 minimizes the effect of tolerance variations in the PGA102's internal resistors, restricting gain error to 0.3%. The circuit's port impedances are analogous to those of a common-emitter transistor, in which source and load impedances reflect to load and source terminals (respectively) and are scaled in proportion to the current gain. In other words, the input impedance is the product of the load impedance and the current gain, and the output impedance is the result of dividing the source impedance by the current gain.

Control current attenuation

The inverse of the current amplifier in **Fig 4a** is the current attenuator in **Fig 4b**. Because of bidirectional current-flow properties, the circuits for amplification and attenuation are similar. The input and output roles, however, are reversed so that the PGA absorbs part of the input current instead of supplementing it. The feedback operation of the attenuator is similar to that of the amplifier, except that all of the input current (I_{IN}) does not flow through R_1. Instead, current flow in that resistor causes feedback to initiate other current drains at the input. The transfer function is linear, and the

By combining the digital-gain-control function with an S/H or V/F function, you can obtain simple circuits with few error-producing components.

PGA102's gain setting controls the output/input current scaling. However, the attenuator's gain is the reciprocal of the amplifier's gain; the output/input relationship is $I_{OUT}=I_{IN}/(1+10G)$.

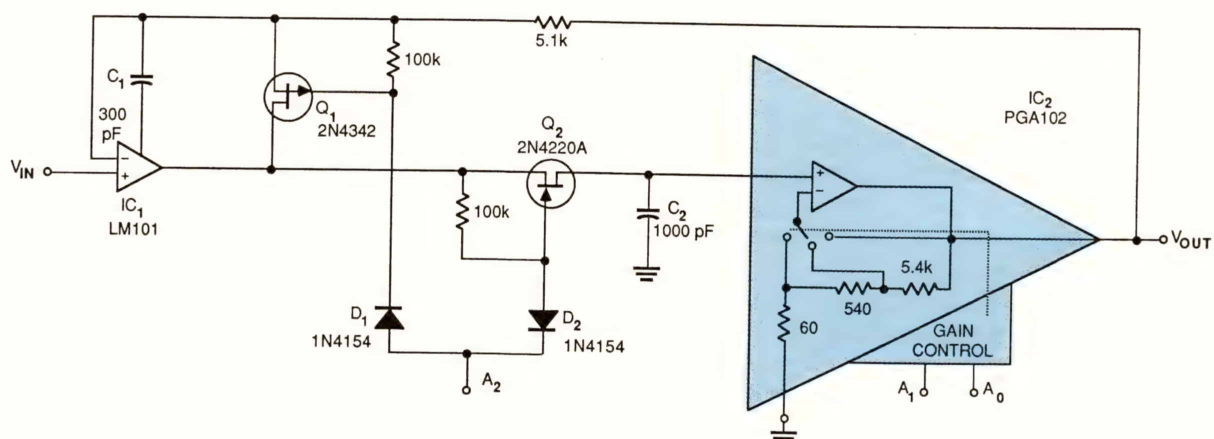
Errors and other performance characteristics for the attenuator are similar to those of the amplifier. The attenuator accepts input currents as high as 5 mA, and the maximum output offset current is 250 nA for the resistor values shown. The circuit's output compliance is reduced by only 0.5V, the PGA retains its full 250-kHz bandwidth, and gain error caused by the PGA102 is no higher than 0.3%. The input impedance is the product of the load impedance and the attenuation factor, and the output impedance is the result of dividing the source impedance by that factor.

By combining the digital-gain-control function with an S/H or V/F function, you can realize simple circuits with few error-producing components. For example, you can build a gain-ranging S/H amplifier that has a 10,000:1 gain range (**Fig 5**). In the circuit, two amplifiers are connected either in a common feedback loop, to sample the signal, or via independent feedback connections, to hold the last signal sample (**Ref 4**). Unless you require greater speed, you'll find this configuration useful for implementing both S/H amplification and signal amplification/attenuation.

Further, by using a PGA102 as the output amplifier, you can enable the circuit to sample at one gain level and then switch to another gain while in the hold mode. (Otherwise, the output amplifier would be a voltage follower that provides unity gain in both modes.)

Digital input A_2 selects either the sample (high) or hold (low) mode of operation. When the circuit is in the sample mode, A_2 applies reverse bias to diode D_2, which allows Q_2 to turn on and complete a feedback loop common to the two amplifiers. The high level on A_2 also creates forward bias across D_1 and turns off Q_1; **Fig 6a** gives an equivalent circuit for this condition. In the equivalent circuit, Q_2 is represented by its on-resistance, R_{Q2}, which provides phase compensation in conjunction with C_2.

While this circuit is in the sample mode (IC_2 has unity



SAMPLE			HOLD			
A_2	A_1	A_0	A_2	A_1	A_0	V_{OUT}
1	0	0	0	1	0	100 V_{IN}(s)
1	0	0	0	0	1	10 V_{IN}(s)
1	0	0	0	0	0	V_{IN}(s)
1	0	1	0	0	0	V_{IN}(s)/10
1	1	0	0	0	0	V_{IN}(s)/100

NOTE: V_{IN}(s) IS THE VALUE OF V_{IN} AT THE END OF THE SAMPLING PERIOD.

Fig 5—By combining an S/H amplifier with a PGA *that can assume different gains in the sample and hold modes, this digitally controlled circuit offers a gain range that is the square of the PGA's gain range.*

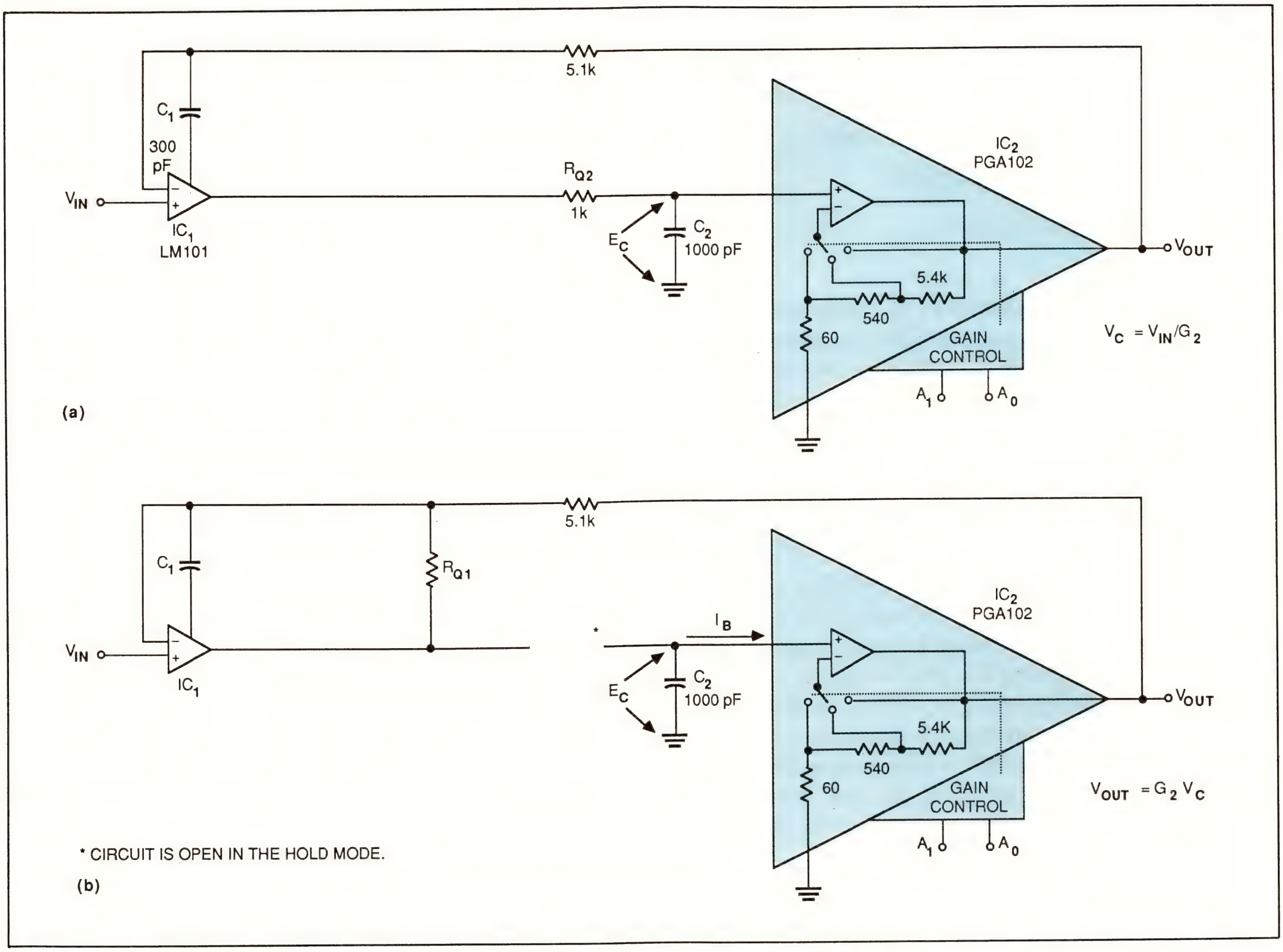


***Fig 6—This circuit provides attenuation** while it's in the sample mode **(a)** and amplification while it's in the hold mode **(b)**.*

gain), the common feedback forces V_{OUT} to track V_{IN}; C_2 charges to V_{IN} as well. C_2 also charges to V_{IN} when the PGA is set for unity gain. When the PGA is set for a higher gain, however, C_2 must charge to a lower voltage to satisfy the feedback constraints. By changing the PGA gain after the circuit switches to the hold mode, you can achieve either amplification or attenuation.

A transition to low on A_2 turns Q_1 on and Q_2 off, thereby switching the circuit to the hold mode; the equivalent circuit for this condition is shown in **Fig 6b**. Switch Q_1's on-resistance shunts IC_1's feedback, preventing IC_1 from saturating and thus delaying overload recovery. Now, V_{OUT} depends only on the voltage stored on C_1 and the PGA's gain. The PGA does double duty, providing attenuation in the sample mode and amplification in the hold mode. Therefore, the S/H amplifier's net gain range is 10,000:1, which is the product of the ranges in each mode (or the square of the PGA's range). Using the table in **Fig 5,** you can calculate the net gain, which you can set from 0.01 to 100 in decade steps.

As you can see from **Fig 5,** the amplifiers' dc errors, the overall bandwidth, and the PGA's gain error all affect the S/H amplifier's accuracy. Further, the net error generally consists of a combination of different gain-error values from both the sample and hold modes of operation. IC_1 contributes almost no gain error because its high open-loop gain provides ample feedback correction within the circuit's bandwidth. The maximum gain error, therefore, equals the worst-case combination of two gain states for the PGA102, or 0.08%.

The dc performance of **Fig 5**'s circuit is limited by the amplifiers' offset-voltage errors and the hold-mode voltage droop produced by IC_2's input bias current. (Droop, which occurs during the hold mode, is a slow discharge of the hold capacitor, C_1, caused by error currents. For the components shown, droop is no greater than 50 μV/μsec.) Although the circuit's offset will change because of contributions from different gains, the net effect is less than 0.01% of full scale.

You can determine the bandwidth of this common-feedback type of S/H amplifier by using the Miller-effect phase-compensation technique. Although the common-feedback configuration lets you use the PGA's gain-ranging feature in both sample mode and hold mode, the configuration does entail multiple response limitations in the common loop. In the sample mode, for example, each amplifier contributes a pole, and the R_{Q1}-C_2 combination contributes a third pole. To be stable, the circuit must have a dominant-pole response for frequencies below the unity-gain crossover frequen-

You can provide digitally controlled gain to a V/F converter by replacing the V/F converter's gain-setting resistor with a programmable gain amplifier.

cy. Capacitor C_1, connected to IC_1's phase-compensation terminal, provides this dominant-pole response. C_1 introduces a frequency rolloff that crosses unity gain at 150 kHz, just where R_{Q2} and C_2 create a second pole. Furthermore, the 5.1-kΩ feedback resistor introduces a zero in this region to cancel the C_1 pole and extend the single-pole response beyond 150 kHz.

To preserve the stability-compensation scheme described above, you must use the Miller-effect phase-compensation scheme. Without the Miller-effect technique, switching the PGA gain would change the loop gain in **Fig 6a**, thus shifting the unity-gain crossover frequency and disturbing the loop's stability. The Miller effect of capacitor C_1, however, varies according to the amount of gain between its terminals. As a result, this changing phase compensation counteracts the destabilizing effect of gain-switching in the PGA, so the unity-gain crossover doesn't move; that is, the circuit's bandwidth remains fixed at 150 kHz.

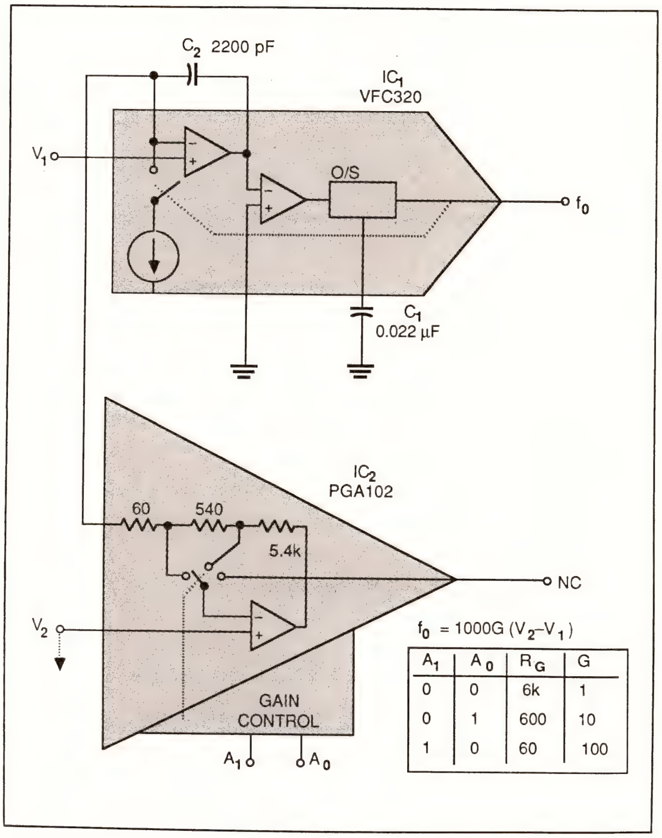
For lower-speed data-acquisition systems using a V/F converter for A/D conversion, you can perform gain ranging at the V/F converter instead of at the S/H amplifier. Charge-balancing V/F converters let you connect the PGA102 in a manner that produces differential inputs. For example, the VFC320 V/F converter lets you simply replace its gain-setting resistor with a PGA102 (**Fig 7**).

The circuit in **Fig 7** creates a virtual ground at the PGA's inverting input by grounding the V_2 terminal. The PGA then switches the virtual ground to various taps on its feedback network, thus supplying the V/F converter with gain-setting resistors of 60Ω, 600Ω, or 6 kΩ. With these resistor values and the other component values shown, the V/F converter can offer a 4-kHz full-scale-frequency response for inputs of 40 mV, 400 mV, and 4V.

By applying a signal to the V_2 terminal instead of grounding V_2, you can obtain a high-impedance differential input without adding an instrumentation amplifier. The differential signal V_2-V_1 will then be impressed across the switchable gain-setting resistor, yielding a proportional output frequency f_O, which is equal to $1000G(V_2-V_1)$, where G is the gain of the PGA102.

Circuit handles common-mode voltage

Common-mode signals shift the V/F converter's integrator output, but have little effect on current in the gain-setting resistor. Because integration over successive cycles of the V/F converter's operation reduces the



A_1	A_0	R_G	G
0	0	6k	1
0	1	600	10
1	0	60	100

Fig 7—To provide digitally controlled gain to a V/F converter, *replace the V/F converter's gain-setting resistor with a programmable gain amplifier.*

effect of common-mode changes, little shift occurs in the average output frequency. Common-mode rejection is 60 dB for the circuit shown. The VFC320's special-purpose integrator amplifier, however, limits the circuit's common-mode voltage range (−10V to +1V).

Although the circuit in **Fig 7** is simple, it has several limitations. First, the V/F converter's gain-setting resistors are confined to the values available from the PGA's feedback network. Further, those resistors have a 20% tolerance that appears directly as gain error, and you must adjust a capacitor value (C_1) to compensate for this error. What's more, the integrator amplifier's gain-bandwidth product at higher gain levels limits high-frequency operation. The integrator must produce a sharp triangle wave to avoid timing errors, but with increased integrator gain, less loop gain is available to preserve the triangle wave's integrity. As a result, the maximum full-scale frequency is 10 kHz.

You can overcome the limitations of **Fig 7**'s circuit by adding an op amp (IC_1 in **Fig 8**). The op amp buffers the

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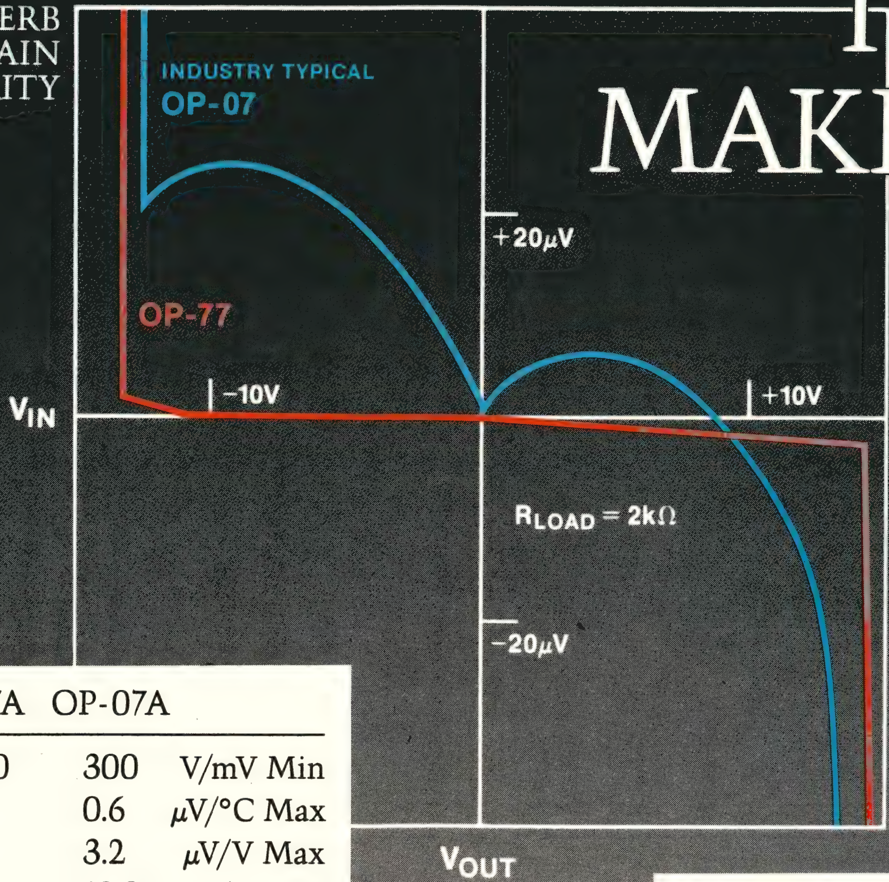

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When you use a PGA102 as the output amplifier in an S/H configuration, the circuit can sample at one gain level and switch to another gain while in the hold mode.

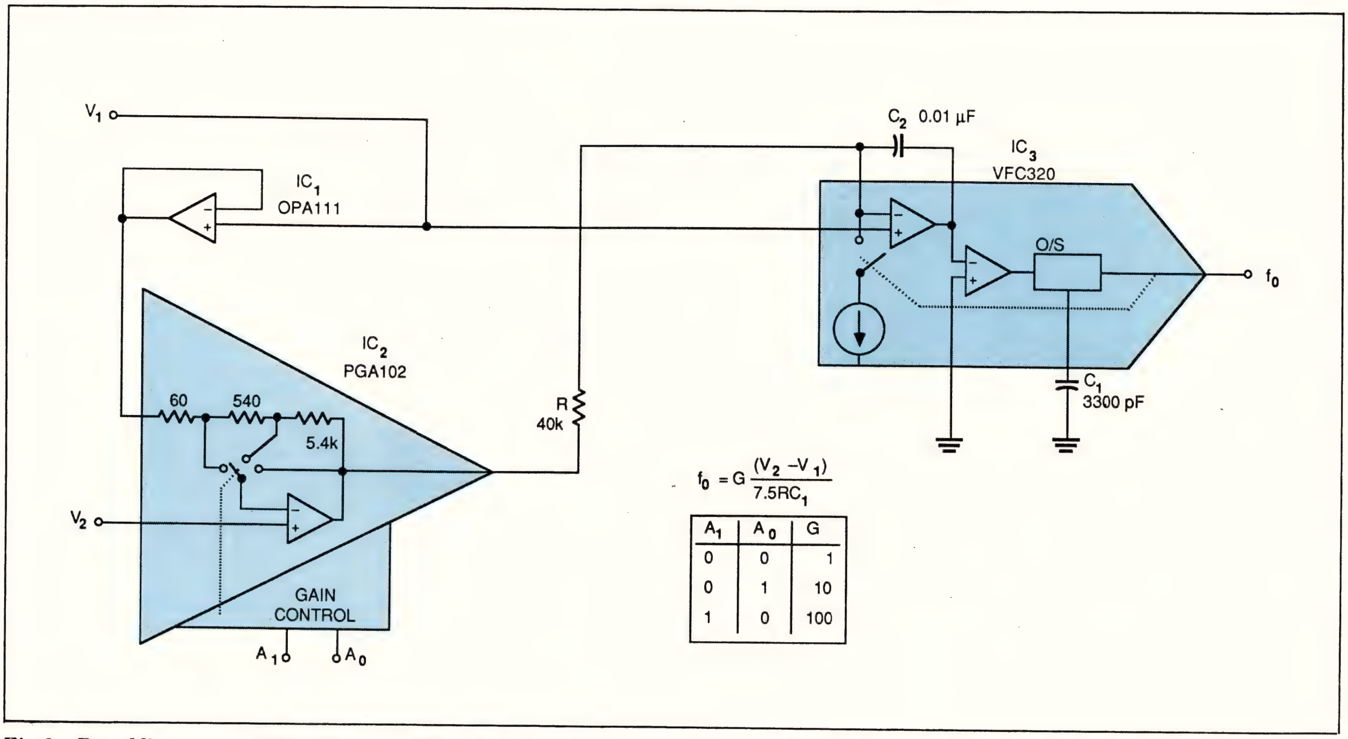

Fig 8—By adding op amp IC₁ to the circuit in Fig 7, you create an instrumentation-amplifier input without affecting either the circuit's frequency range or its digital-gain-control capabilities.

normally grounded feedback return of the PGA102, so the PGA now drives an external V/F converter's gain-setting resistor. You can select that resistor value for the more conventional 10V FS inputs, and you can adjust the resistor value to remove gain errors. Because the gain-setting resistor is no longer switched, the integrator's feedback factor remains constant, so the V/F converter's gain-bandwidth requirement doesn't change. The PGA has a varying feedback factor, but it only has to process the low-frequency input signal. In short, you can set the circuit's full-scale frequency as high as 1 MHz, which is the VFC320's upper limit.

Like the circuit in **Fig 7**, this circuit has high-impedance differential inputs. With its various gains, the PGA presents a prescaled signal to the V/F converter's gain-setting resistor (R); the common-mode signal characteristics remain the same as in **Fig 7**. The circuit's nonlinearity is 0.015%, and you can trim its input offset error to 0.5 mV. **EDN**

Article Interest Quotient (Circle One)
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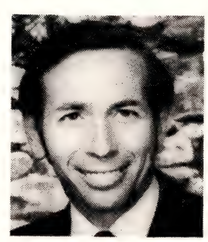
References

1. Graeme, J, *Designing with Operational Amplifiers: Applications Alternatives*, McGraw-Hill, 1977, pg 29.
2. Graeme, J, "Feedback lowers AGC distortion," *EDN*, January 7, 1981, pg 202.
3. Graeme, J, "Manipulate current signals with op amps," *EDN*, August 8, 1985, pg 147.
4. Tobey, G, J Graeme, and L Huelsman, *Operational Amplifiers: Design and Applications*, McGraw-Hill, 1971, pg 353.

Author's Biography



Jerald Graeme is manager of instrumentation components design at Burr-Brown Corp (Tucson, AZ), where he directs a linear-IC-development group. Jerry, who has been with the company for 20 years, received a BSEE from the University of Arizona and an MSEE from Stanford University. He has had 7 patents granted. His spare-time activities include photography, scuba diving, and woodworking.

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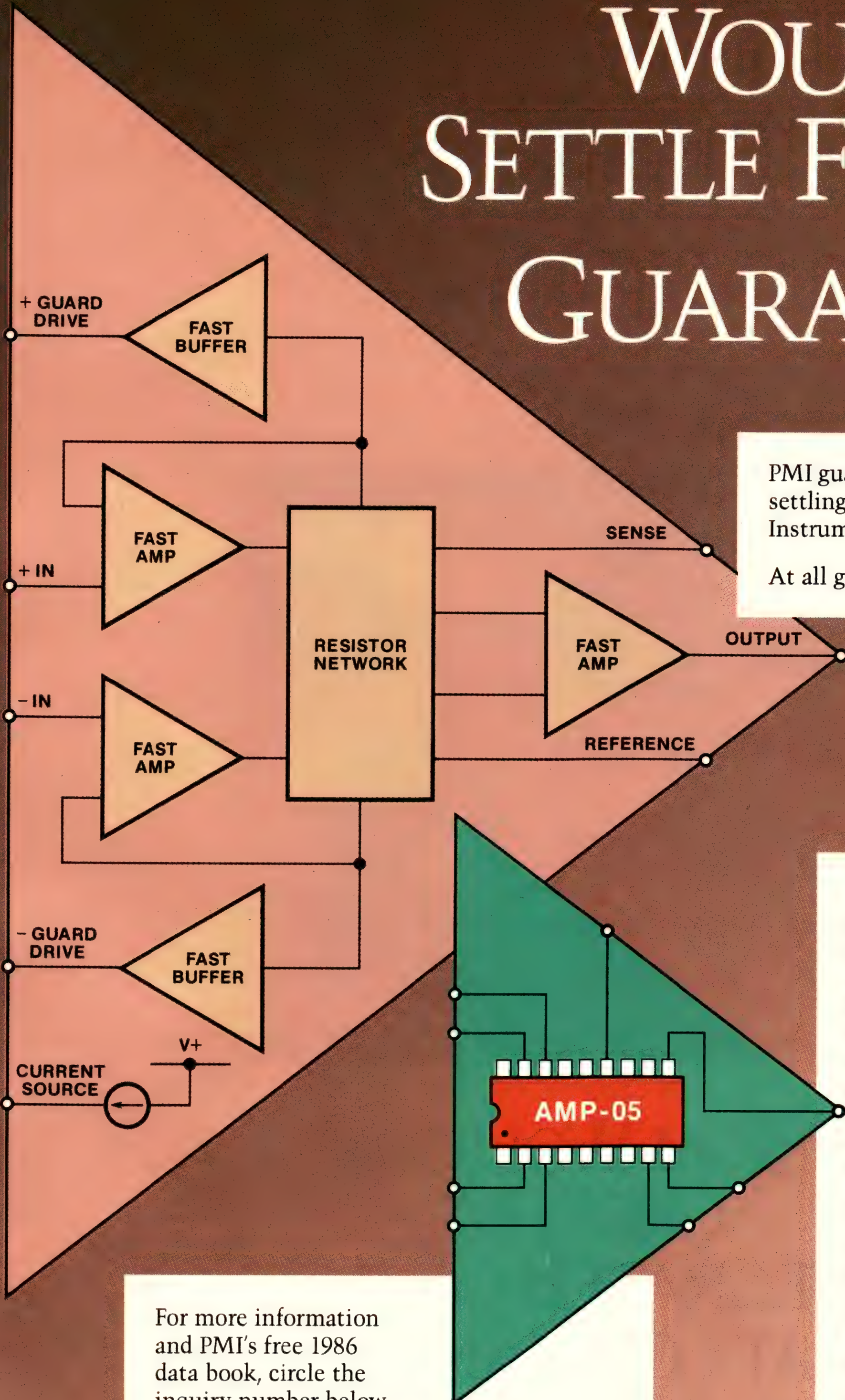

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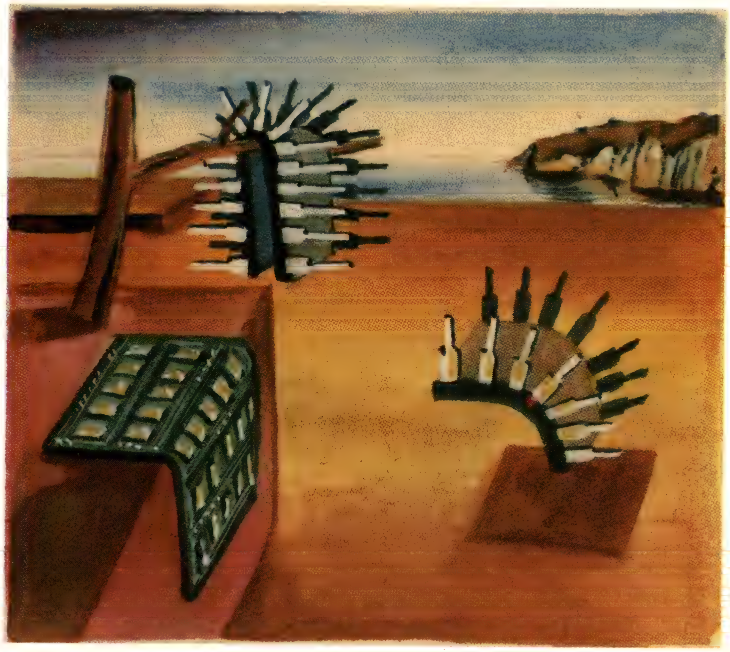

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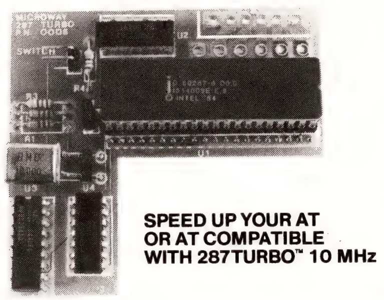

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Robert Widlar and Mineo Yamatake,
National Semiconductor Corp

By eliminating the need to design discrete power-transistor circuitry, the 150W LM12 single-chip op amp can greatly simplify your design tasks. For instance, by using parallel-connection and bridge-connection techniques, you can obtain more current or voltage swing than you could from a single LM12. The op amp can also simplify the design of such circuits as audio amplifiers, servo amplifiers, and voltage regulators.

When you need to obtain even more current than one LM12 can deliver, you can connect two or more of the devices in parallel, as in **Fig 1a.** The power op amps, IC_2 and IC_3, are wired as followers and connected in parallel; their outputs are coupled through equalization resistors R_4 and R_5. To meet even higher drive requirements, you can add more output buffers, each with its individual equalization resistor. The LM144 high-voltage op amp (IC_1) provides voltage gain. The overall negative feedback compensates for the voltage dropped across the equalization resistors.

The parallel operation of the amplifiers increases the unloaded supply current; this increase is related to the offset voltage of IC_2 and IC_3 across the equalization resistors. In some cases (for example, in the presence of reactive loads), you may need to use input compensation for the followers to increase stability. Make sure, however, that the source resistance introduced by the input compensation doesn't increase the offset voltage excessively.

A method of paralleling op amps that doesn't require a separate control amplifier is shown in **Fig 1b.** The output buffer, IC_2, provides load current through R_5; this load current is equal to the current supplied by the main amplifier (IC_1) through R_4. Again, to meet even higher drive requirements, you can add more output buffers. Gain error can affect the cross-supply current between the outputs of parallel-connected amplifiers as the circuit approaches its power-bandwidth limit.

In the circuit in **Fig 1a**, the operating-current increase is a function of how closely the op amps' high-

You can increase output-voltage swing by using op amps in a bridge configuration; connecting multiple op amps in parallel increases current-handling capability.

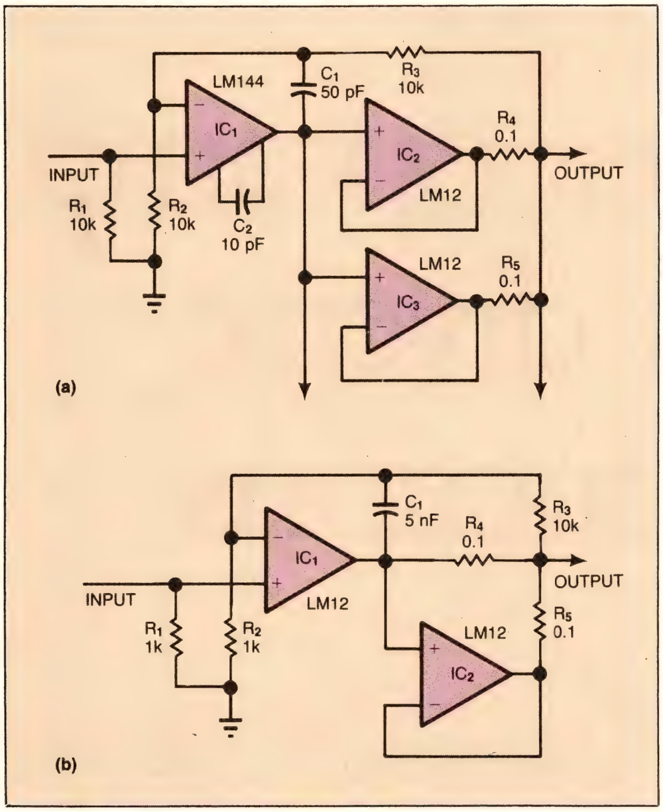

***Fig 1—You can increase an amplifier's power** by connecting op amps in parallel. In **a,** IC_2 and IC_3 are connected as voltage followers; in **b,** IC_1 and IC_2 form a master/slave combination.*

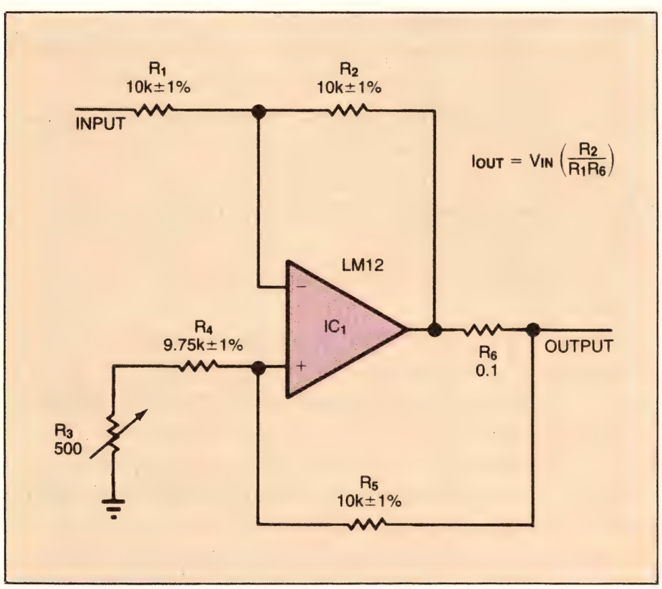

***Fig 2—This voltage-to-current converter** requires tight resistor matching or trimming in order to present high output resistance. Be aware that the inductance of R_6 can reduce the circuit's bandwidth.*

frequency characteristics are matched. In the circuit in **Fig 1b,** however, the entire input error of IC_2 appears across R_4 and R_5. The supply-current increase can activate the op amps' power-limiting mechanism as the amplifiers' outputs approach their slew limit; the LM12 won't be damaged. You can avoid the frequency-related problems in both circuits by changing the circuits to inverting-amplifier configurations and restricting the bandwidth to a value determined by C_1.

Convert voltage to current

Current drive helps stabilize servo loops by reducing the phase lag resulting from motor inductance. Current drive is, therefore, often preferable to voltage drive for driving servomotors. The circuit in **Fig 2** provides an output current that's proportional to the input voltage. In applications requiring high output resistance (such as operational power supplies running in the current mode), either you'll need to match the feedback resistors to 0.01% or tighter, or you can use an adjustable resistor (R_3) to maximize the output resistance. Offsetting R_3 from its optimum value results in a decrease in positive or negative output resistance.

The input to **Fig 2**'s current source is actually differential. You can drive it as shown, or, to obtain the opposite output sense, you can drive it from the bottom of R_3. To avoid unbalancing the feedback, thus changing the output resistance, you can take one of two actions: You can connect both inputs to a low source impedance, such as ground or an op amp's output, or you can drive an input from a source whose resistance is known, as long as you take this resistance into account in determining the feedback network.

The frequency characteristics of the current source can be expressed in terms of an equivalent output-load capacitance defined by

$$C_{eq} = \frac{R_1 + R_2}{2\pi f_0 R_1 R_6},$$

where f_0 is the extrapolated unity-gain bandwidth of the op amp (approximately 2 MHz for the LM12). The equation is valid only for $Z_L >> R_6$.

This output capacitance can resonate with inductive loads such as motors, and the resonance can cause some peaking. If the feedback-network imbalance yields a high enough negative output resistance, the inductive loads can oscillate.

Inductance in the current-sense resistor, R_6, can adversely affect the high-frequency performance of the

voltage-to-current converter. For example, 3-μH series inductance in a 0.1Ω sense resistor reduces the maximum obtainable bandwidth to 5 kHz. For the circuit in **Fig 2,** you should apply adequate supply bypassing and connect R_2 directly to the op amp's output pin.

Although op amps usually operate from dual power supplies, you can use a single supply in many applications. The bridged amplifier in **Fig 3,** for example, supplies bidirectional current drive to a servomotor and operates from a single positive supply. Op amp IC_1 is a voltage-to-current converter with a differential input. The second amplifier (IC_2) is a unity-gain inverter that obtains its drive from the output of the first. Its noninverting input connects to a voltage that's half the supply voltage, so the two outputs swing symmetrically about this voltage.

You can ground either input and provide bidirectional drive to the other. You can also connect one input to a positive reference; the signal to the other input varies about this reference voltage. If the reference voltage is greater than 5V, you don't need R_2 and R_3.

You can easily convert the output to voltage drive by short-circuiting R_6 and connecting R_7 to the output of IC_2, rather than to that of IC_1. Although they're not shown in **Fig 3,** clamp diodes connected from both amplifiers' outputs to $+V_S$ and ground provide output protection when you use **Fig 3**'s circuit to drive a motor.

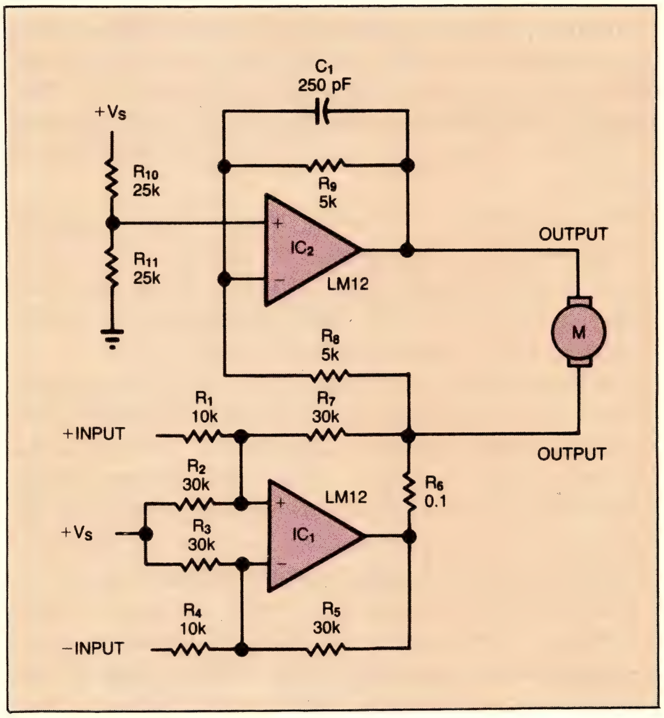

*Fig 3—**Providing twice the output swing** of a single amplifier, this circuit delivers output current that's proportional to the differential input voltage. Although clamping diodes aren't shown in the schematic, you'd do well to connect them to the outputs because of the inductive nature of the motor load.*

Increase available swing

Using two amplifiers in a bridge connection doubles the voltage swing delivered to the load. The configuration in **Fig 4** is a bridge circuit that uses dual supplies. One op amp is an inverting amplifier; the other is an equal-gain noninverting amplifier. A load connected between the outputs receives twice the voltage swing available from either amplifer. Note that, in comparison with single-amplifier circuits, the bridge circuit's output slew rate doubles and the full-power bandwidth stays the same.

You can't expect the current limits of two op amps to be the same. Therefore, a short circuit between the outputs of a bridge amplifier can cause one amplifier to saturate while the output transistor of the second handles the overload at the full supply voltage. The LM12, unlike many other power amplifiers, can survive this kind of treatment. To protect the amplifiers' output circuitry against inductive-load problems, use the bridge-rectifier module in **Fig 4** to provide output clamping for both outputs.

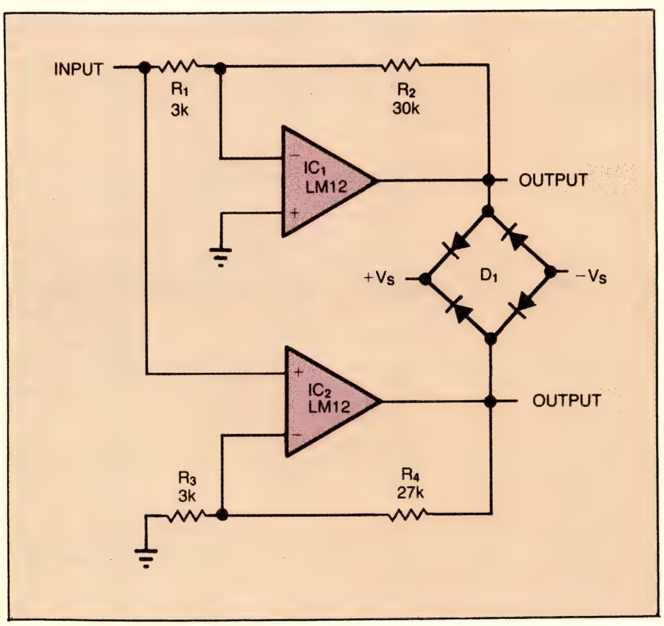

*Fig 4—**These bridge-connected amplifiers** double the available output swing and yield a differential output that approaches twice the total supply voltage. The diode bridge clamps the outputs to the supply levels.*

To avoid instability induced by the phase lag a motor's inductance produces, use current-drive circuit configurations rather than ones that provide voltage drive.

To obtain output swings several times higher than those available from the basic LM12, you can operate the amplifier in cascode with external transistors. The design in **Fig 5** supplies ±90V at ±10A. Note that the IC provides current and power limiting for the external transistors.

The transistors and zener diodes form a simple voltage regulator that obtains its drive at 70% of the output swing from the R_7/R_9 divider. Thus, the total supply voltage of the IC stays constant even as the voltage to ground swings approximately ±60V.

The supply-terminal voltages of the LM12 swing both above and below ground at full output. Therefore, you must bootstrap the input terminals to the output to keep the input voltages within the common-mode range. The R_1-R_4 bridge provides the bootstrapping. R_5 unbalances the bridge to set the gain near 30. Naturally, you can replace R_4 and R_5 with a single resistor.

Bootstrapping the op amp's supply voltages reduces the voltage swing across the LM12's internal frequency-compensation capacitors. The effectiveness of the capacitors is proportional to the output swing across them. If the voltage swing between the output and $-V_S$ terminals of the IC is one-third the actual output swing, the slew rate and gain-bandwidth product of the complete amplifier will be three times those listed for the IC. You must increase the minimum loop gain accordingly.

Because the op amp has limited supply rejection at high frequencies, distortion on the bootstrapped supplies can appear on the output. If the values of R_6 and R_8 are not low enough, the circuit's speed performance will suffer because the power followers won't be able to track high-frequency waveforms.

The circuit in **Fig 5** is more sensitive to capacitive loading than is the basic op amp, because you can't bypass the supply terminals of the IC directly to ground. You can mitigate the effects of capacitive loads by using an appropriate LR network in the output.

When the IC goes into power limit, current limiting will also take place in the external transistors. The voltage on these external transistors is not necessarily regulated, so in order to handle the extra voltage, the discrete transistors must be sufficiently more robust than the IC's transistors. The IC can handle many more power cycles than can commercial power transistors that use soft-solder die attach. Avoid cycling in and out of power limit at low frequencies; such cycling could destroy the discrete transistors.

If you have floating power supplies, you can increase

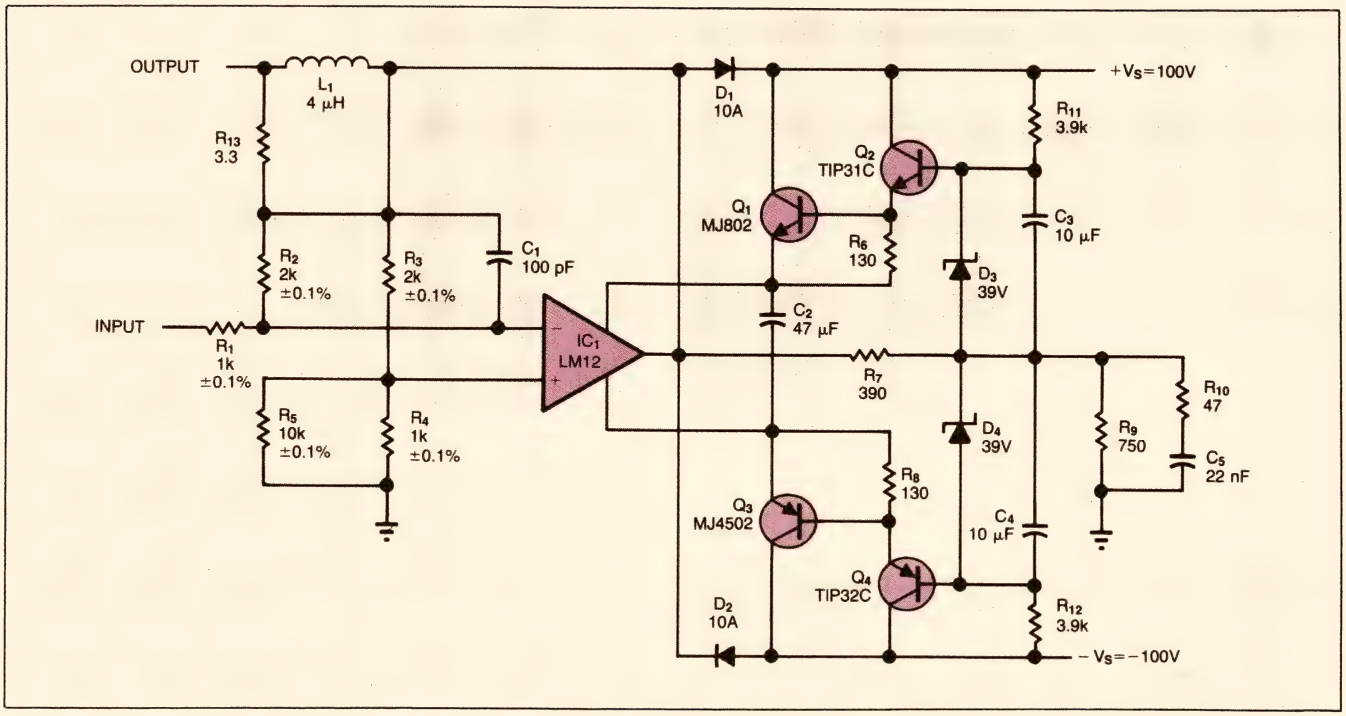

***Fig 5—Use external transistors** to increase the available output voltage. This amplifier can supply ±90V at ±10A, which is twice the output swing available from the LM12. The IC provides current limiting and power limiting for the discrete transistors.*

the output swing by using more conventional circuitry. **Fig 6** shows a bridged amplifier that drives a ground-referred load. The circuit has differential inputs, but you can ground one input and drive the other from a low-impedance source. If the noninverting input is grounded, you can replace R_7 and R_8 with a single resistor. The circuit operates in the same manner as a standard bridge does, except that this circuit is somewhat more sensitive to capacitive loading. Its output swing is ±70V at ±10A.

Fig 7 shows how you can double output swing by stacking two op amps. To triple the basic swing, you can add a third op amp, with a gain of 0.5, to the output. You can cascade any number of op amps in order to add to the swing, but you must provide a floating supply for each. In a 2-stage circuit, you should use clamp diodes from each amplifier's output to its supply terminals. In a circuit using three or more stages, you need the diodes in order to avoid supply reversals.

R_4 and C_3 limit the bandwidth of the circuit in **Fig 7.** This RC isolation also prevents output load transients (which are reflected back to the output of IC_1) from regenerating. This regeneration shows up as capacitive-load sensitivity. As with the other designs, an output LR network will help reduce sensitivity to capacitive loading.

You can use the LM12 to design a high-quality audio amplifier (that is, an amplifier that has tight distortion specifications). **Fig 8a** shows a practical design for an audio power amplifier. You must use clamp diodes at the output, because loudspeakers are inductive loads. Because audio amplifiers must usually handle as much as 2 μF of load capacitance, the circuit also uses output LR isolation. Large supply-bypass capacitors are close to the IC, so the rectified load current in the supply leads doesn't get back into the amplifier and thus increase high-frequency distortion. To avoid ground loops that can increase distortion, you should use single-point grounding for all internal leads, as well as for the signal source and load.

Fig 8b plots the total harmonic distortion measured for the circuit in **Fig 8a.** The increase in distortion at high frequencies arises from crossover distortion in the class-B stage. The increase at low frequencies is caused by thermal feedback within the LM12. The effect of thermal feedback on the response of the LM12 is indicated in **Fig 9.** The offset-voltage change is plotted as a function of time after applying an output load that dissipates 50W in the source and sink transistors.

You can virtually eliminate low-frequency distortion (unlike crossover distortion) by using the LM12 as a buffer inside the feedback loop of a low-level op amp. However, the low-frequency (thermally generated) harmonic distortion is slow, and it doesn't cause the more objectionable intermodulation distortion. The IM distortion measured 0.015% at a ±10V output level into a 4Ω load under the standard 60-Hz/7-kHz, 4:1 test conditions.

The transient response of the circuit in **Fig 8a** is clean, and the saturation characteristics are glitch-free

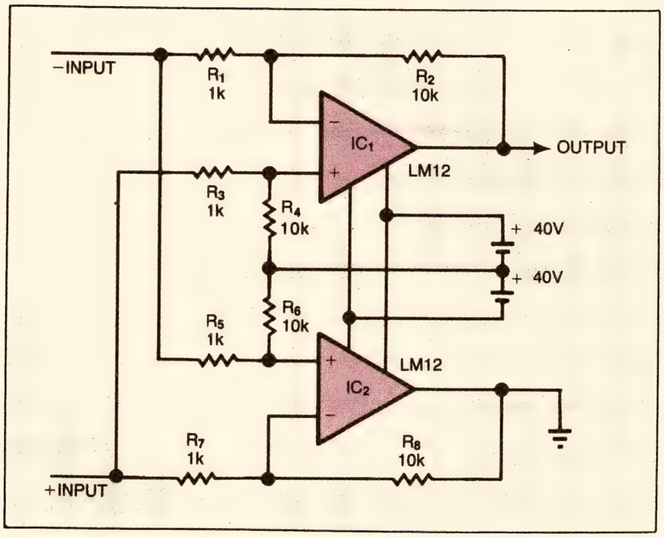

Fig 6—Floating supplies *allow this bridge amplifier to provide a single-ended output. You can ground either input.*

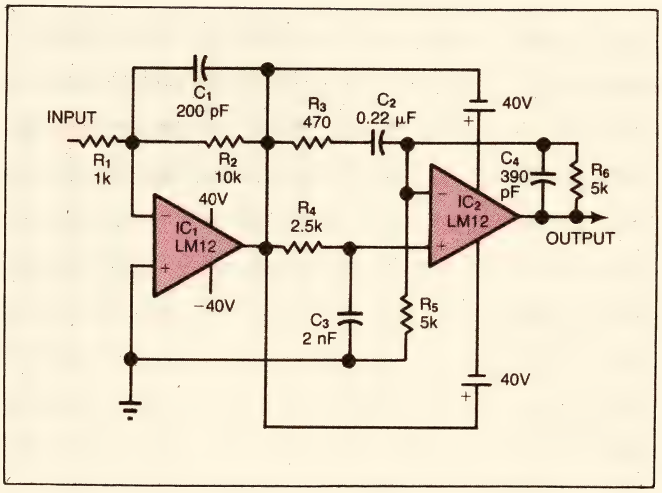

Fig 7—Cascading two op amps doubles the available output swing. *You can further increase the available output by adding any number of stages, but you'll need a separate, floating power supply for each stage.*

You can double output swing by stacking two op amps. To triple the basic swing, you can add a third op amp, with a gain of 0.5, to the output.

even at high frequencies. The 9V/μsec slew rate of the LM12 virtually eliminates transient intermodulation distortion.

In systems using fast, motor-driven servos, it's best to make the motor current proportional to the servo amplifier's input drive. If you use current drive, the motor response will basically be insensitive to the series inductance of the motor windings. At higher frequencies, current drive can give 90° less phase shift in the motor's transfer function than can voltage drive. However, if the servo loop goes through unity gain at a frequency at which motor inductance is unimportant, you don't have to use current drive.

The motor/tachometer speed-control circuit shown in **Fig 10** gives an example of how to optimize performance using current drive. IC_2, connected as a voltage-to-current converter, supplies the drive. The tachometer, on the same shaft as the dc motor, is simply a generator; it gives a dc output voltage that's proportional to the speed of the motor. A summing amplifier (IC_1) controls the tachometer's output so that the tachometer's voltage equals the input voltage, but is of opposite sign.

Because of the current drive to the motor, the phase lag to the tachometer reaches 90° before second-order effects appear. IC_1's compensation is designed to give less than 90° phase shift over the range of frequencies at which the servo loop goes through unity gain. If response time is of minor concern in your application, you could use a power op amp for IC_1, which would drive the motor directly. Of course, you would need to lower the break frequencies of the compensation.

To use the circuit in **Fig 10** as a position servo, you

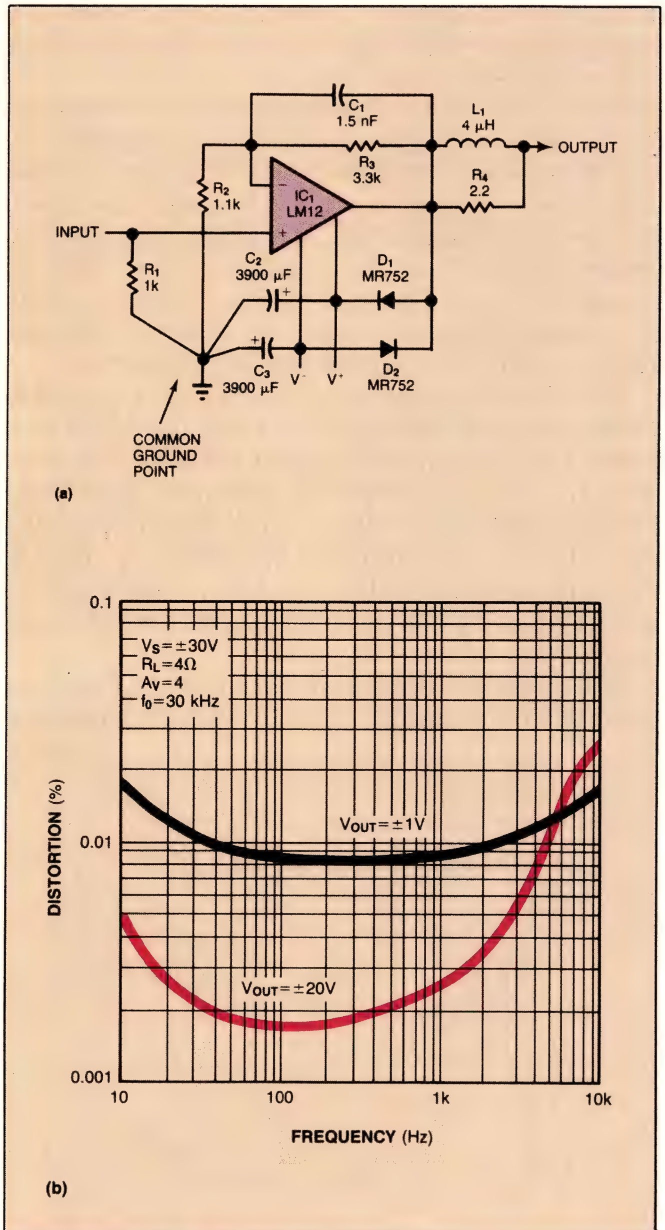

Fig 8—Low distortion, fast transient response, and fast saturation recovery *are the hallmarks of the audio amplifier in* ***a****. The curves in* ***b*** *plot total harmonic distortion vs frequency for both low- and high-level outputs.*

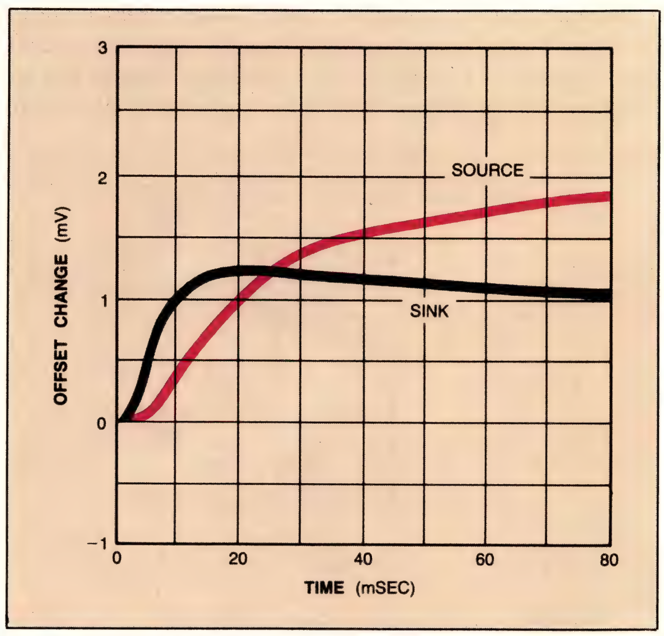

Fig 9—Thermal feedback in the LM12 causes increased distortion *at frequencies below 100 Hz in* ***Fig 8's*** *circuit. These curves show the offset-voltage change in a typical LM12 after the application of a load that causes 50W dissipation in each output transistor.*

simply provide a voltage that indicates the sense and magnitude of the motor shaft's displacement from a desired position. This error signal connects to the input, and the servo works to make the voltage zero. The tachometer is still required to develop a phase-correcting rate signal, because the error signal lags behind the motor-drive signal by 180°.

To understand the concept of a rate signal, consider a simple example. Assume that you must rotate a radar antenna to acquire a target from a large angle-off point. When the motor has limited power and the antenna has mass, the quickest path into point is to run full-bore toward point, to pick the correct instant to reverse at full power before getting there, and to shut down in just the right place. In a servo, the rate signal (which is added to the error signal) tells the servo when to reverse so that the servo system can acquire the target without overshooting.

In a system using a fixed target, a tachometer on the drive motor will give the rate signal. If the target is moving across the antenna, the tachometer doesn't provide the rate signal; instead, it produces the rate signal plus or minus the angular velocity of the target, thus disrupting acquisition and generating a pointing error.

You can obtain the rate signal by differentiating the error signal. The circuit in **Fig 11a** is a design that gives the required error signal and the rate signal at the output. Neither op amp should saturate under any condition, no matter how far off point or how fast the error changes. If saturation occurs, the circuit can't develop a correct rate signal, and the result is degraded acquisition. This situation can degenerate to a point

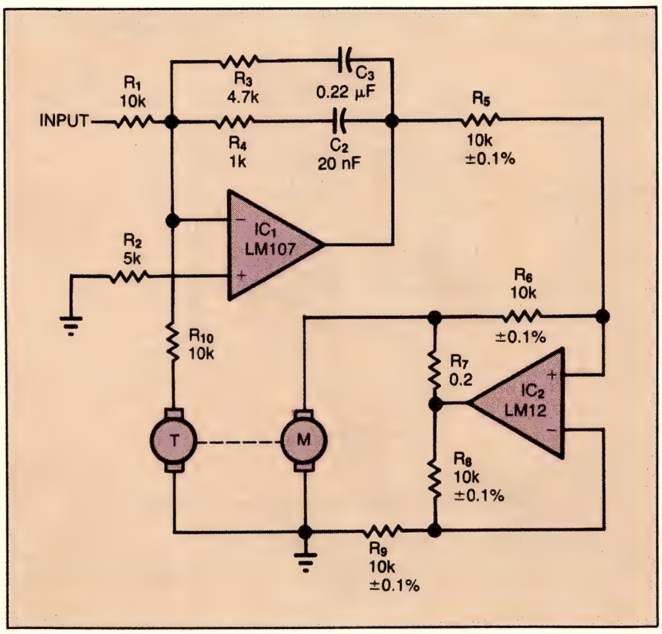

***Fig 10—This servomotor-tachometer arrangement** yields an output speed that's proportional to input voltage. The use of current drive to the motor reduces loop phase shifts arising from the motor's inductance.*

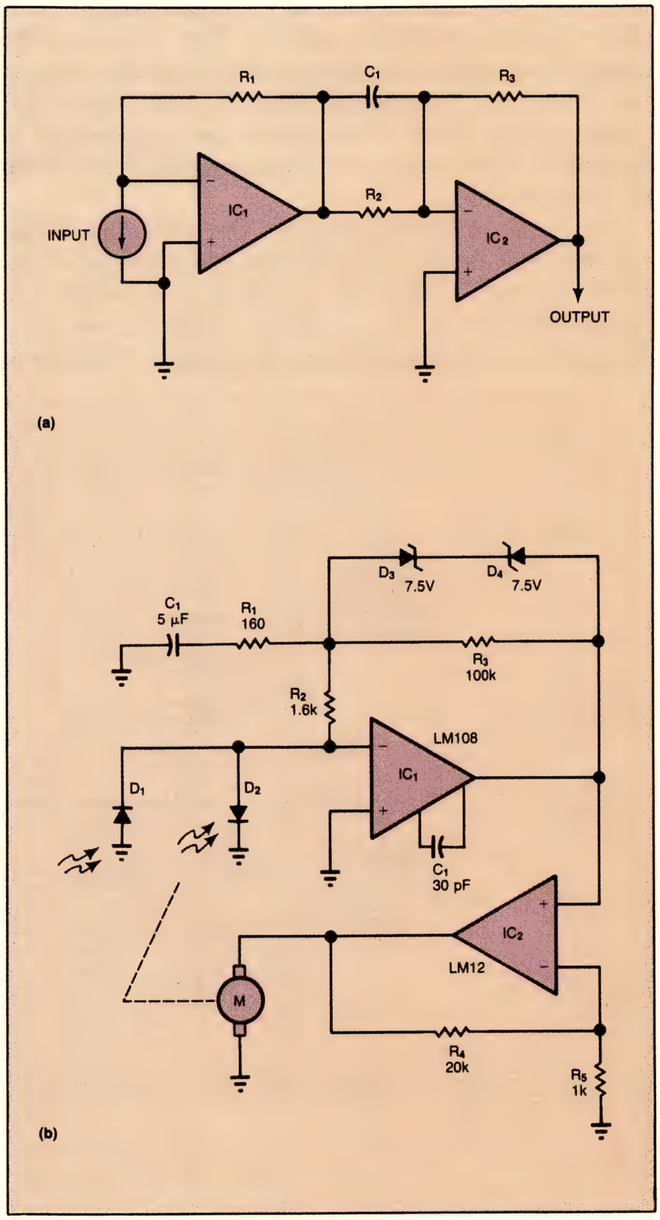

***Fig 11—To develop electrical rate signals** in the presence of large error signals beyond the point of motor-drive saturation, you can use the linear approach in **a**. This method requires wide dynamic range and high precision. The more practical design in **b** uses feedback clamps to increase the effective dynamic range.*

You can virtually eliminate low-frequency distortion by using the LM12 as a buffer inside the feedback loop of a low-level op amp.

where the servo will oscillate continuously once the tracking error exceeds a certain amount.

Quick and accurate acquisition from large errors requires an extremely wide dynamic range. In **Fig 11a,** you must make R_1 and R_3 so low—to keep the amplifiers from saturating—that you might need to use chopper stabilization to preserve accuracy. In **Fig 11a,** you can raise R_3 to any value as long as you install back-to-back zener diodes across the resistor. The waveform for signals lower than the clamp level will be the same as the waveform that appears when IC_2 has unbounded output swing. If the clamp levels are high enough to saturate the motor drive, the clamping won't impair the driver's operation.

The circuit in **Fig 11b** develops the preceding clamping principle further. This circuit gives the same response as that in **Fig 11a,** except that the resistor in series with C_1 breaks back the differentiator at a frequency above the unity-gain frequency. If the servo shaft is at an off-point angle, you must make sure that the voltage at the junction of R_1 and R_2 doesn't become so large that the clamps must conduct in order for IC_1 to saturate IC_2.

Circuit implements operational power supply

You can provide external current limiting for an op amp as shown in **Fig 12.** You can set the positive and negative limiting currents precisely and independently to levels as low as zero by using potentiometers R_3 and R_7. Alternatively, you can program the limit from voltages supplied to R_2 and R_6. The input controls the output when the circuit is not in current-limit mode. This circuit is suitable for use as an operational power supply or a voltage-programmable power source.

The power op amp, IC_4, is connected as an inverting amplifier. IC_3 senses IC_4's output current across R_{15} and level-shifts the sense voltage to ground. IC_3 is a differential amplifier. You make IC_3 insensitive to the op

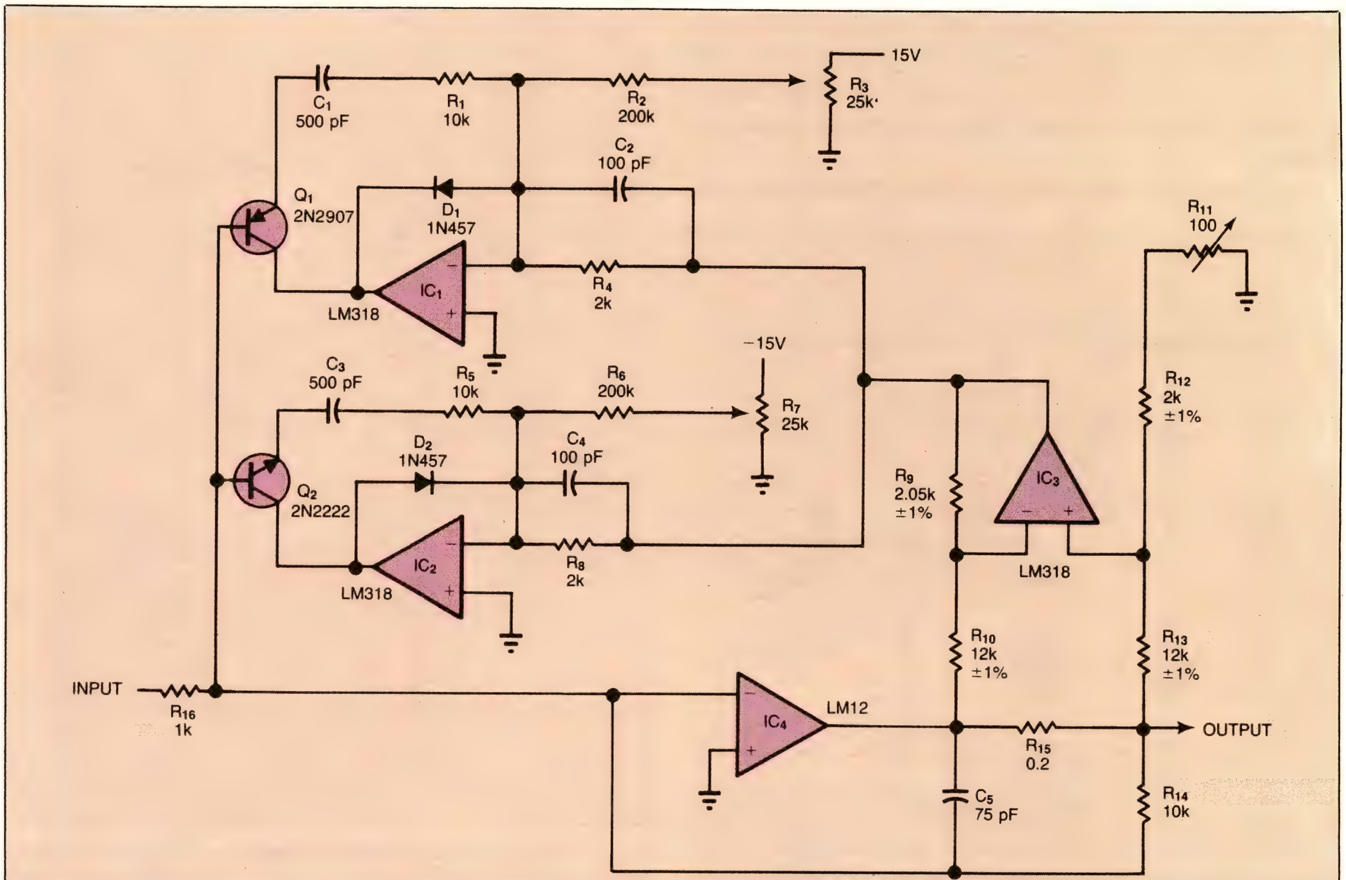

Fig 12—Potentiometers R_3 and R_7 set the bidirectional limiting currents *in this power-op-amp configuration. The clamp diodes around IC_1 and IC_2 ensure fast response.*

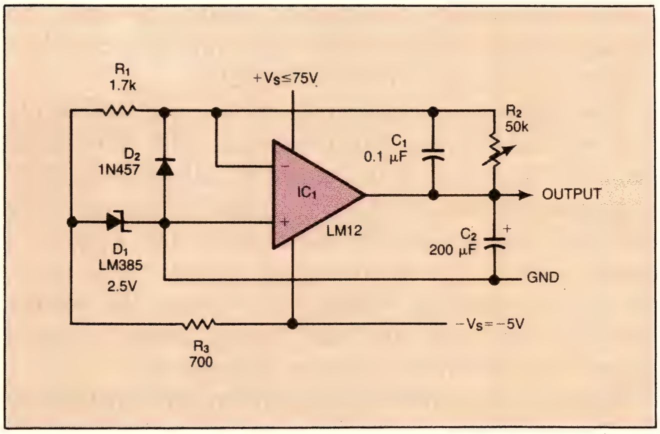

Fig 13—Providing 0 to 70V output, *this positive voltage regulator can both sink and source current. The start-up capability of this circuit in the presence of high input voltages is superior to that of dedicated IC regulators.*

amp's output level by trimming R_{11}.

If the positive and negative currents are below the preset levels, D_1 and D_2 clamp the outputs of IC_1 and IC_2, and Q_1 and Q_2 turn off. When the current reaches the threshold, the relevant amplifier comes out of clamp, saturates the transistor on its output, and takes control of the summing node. The transistors disconnect the frequency compensation until the summing node is engaged; during this interval, the clamp diodes limit the swing on the outputs of the current-control amplifiers. The disconnection of compensation ensures that the current-limiting function will be activated quickly. Recovery from the current-limiting mode to the voltage mode is also fast. Note that IC_1 through IC_3 must be wideband amplifiers, such as LM318s.

Op-amp regulator improves transient response

You can use an op amp as a positive or negative regulator with equal ease. Unlike the outputs of most dedicated voltage regulators, an op amp's output can both source and sink current; the output can thus absorb energy dumped back into the supply and prevent overvoltage under certain fault conditions. And, in comparison with a dedicated regulator, an op-amp-based regulator provides better output transient response, especially in terms of overshoots.

Because of its exceptionally high voltage capability, the LM12 functions well as a regulator. This capability not only yields output voltages to 70V, but also ensures that the regulator will start up under worst-case (full-load) conditions.

Compared with conventional IC regulators, an op amp with an external reference provides better accuracy—you can select an optimum reference and thermally isolate it from the power circuitry. The regulator will provide improved regulation, temperature drift, and long-term stability. To further reduce errors, you can use remote output-voltage sensing at the load.

Fig 13 shows a positive regulator whose output range is 0 to 70V. The op amp has one input at ground; a reference current set by the low-power bandgap reference D_1 flows away from the summing junction. In this arrangement, output voltage is proportional to the setting resistor (R_2). A negative supply makes the op amp operate within its common-mode range, allows the op amp to yield 0V output when sinking current, and powers reference D_1. Current drawn from this supply is less than 150 mA, except when the circuit sinks load current.

The output load capacitor, C_2, is part of the op amp's frequency compensation. This compensation technique requires that you connect C_1 directly at the op amp's output and C_2 at the load **(Ref 1).** C_1 filters the reference's noise and also controls the start-up rate. The clamp diode, D_2, resets C_1 when the output is short-circuited and prevents the op amp's input from reaching voltages below $-V_S$.

You don't need dual supplies in order to use an op amp as a regulator, as you can see from the 4 to 70V adjustable regulator shown in **Fig 14.** This regulator also has overvoltage protection. If an overvoltage condition exceeds the current or power capabilities of the LM12, a comparator triggers SCR Q_3, thus crowbarring the output.

The reference is a low-drift zener diode, D_1, that's powered by $+V_S$ through R_1. The reference voltage, dropped to 4V by the R_2/R_3 divider, is applied to the noninverting input of op amp IC_1. C_1 attenuates the zener-diode noise. Thus, the op amp's output is this 4V plus a voltage that's proportional to the resistance of R_9. As before, D_2 is a clamp; C_2 ensures ac coupling of the IC's input directly to its output terminal.

Under overvoltage conditions, a comparator (IC_2) fires the SCR through a buffer, Q_2, after about a 20-μsec delay (to eliminate spurious transients) that's produced by C_3. Because the comparator receives its power from Q_1, you can increase $+V_S$ to a voltage higher than the rating of the LM311.

If the voltage at the op amp's feedback terminal rises more than 0.4V above the regulating value for longer than 20 μsec, the comparator will provide the signal required to fire the SCR. Because the firing signal can

In systems using fast, motor-driven servos, it's best to make the motor current proportional to the servo amplifier's input drive.

occur only if the considerable current and energy capabilities of the LM12 are exhausted, nuisance tripping is unlikely. The output trip threshold will be 0.4V above nominal as long as the overvoltage condition arises quickly enough that the voltage across C_2 does not change appreciably. For a slow overvoltage condition, the trip threshold is 10% above the nominal regulating value.

Remote sensing cuts drops

If a foot of 0.1-in.-diameter wire carries a current of 10A, the wire's resistance causes a voltage drop of 10 mV. Unless you use expensive and cumbersome cables, you usually have to accept sizeable voltage drops when you run such high currents over any distance. Remote sensing, however, can improve the situation considerably **(Fig 15)**. This method uses a pair of small wires, independent of the main power cables, to sense the voltage at the load. A feedback amplifier can then correct for the drop in the main cables.

The cables can cause delays in the feedback signal that returns from the remote-sensing point. This delay can make the feedback loop unstable unless the amplifier ignores the remote signal at higher frequencies. You can thus compensate for cable drop, but only to a certain extent: The compensation scheme is detrimental to the transient response. To incur the fewest delay-induced problems, use heavy cables, closely spaced (or twisted) to minimize inductance.

Fig 15 shows a differential-input amplifier that has dc feedback from the remotely sensed load. The ac feedback comes directly from the op amp's output and the signal common at the sending end. No feedback comes from the load at high frequencies. The optimum capaci-

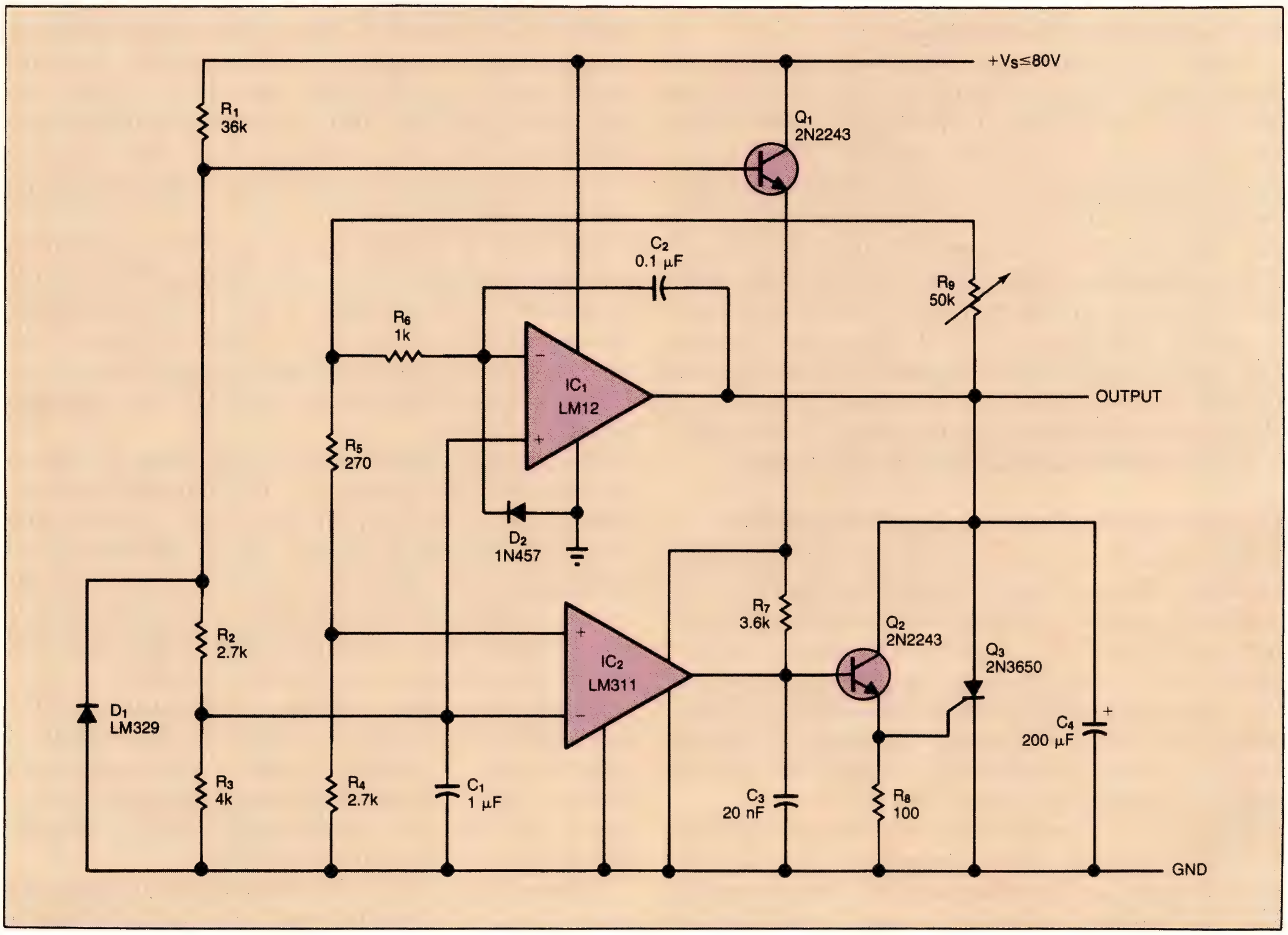

Fig 14—This 4 to 70V regulator operates from a single supply. *For overvoltage conditions beyond the capabilities of the LM12, the SCR (Q_3) introduces a crowbar short circuit from output to ground.*

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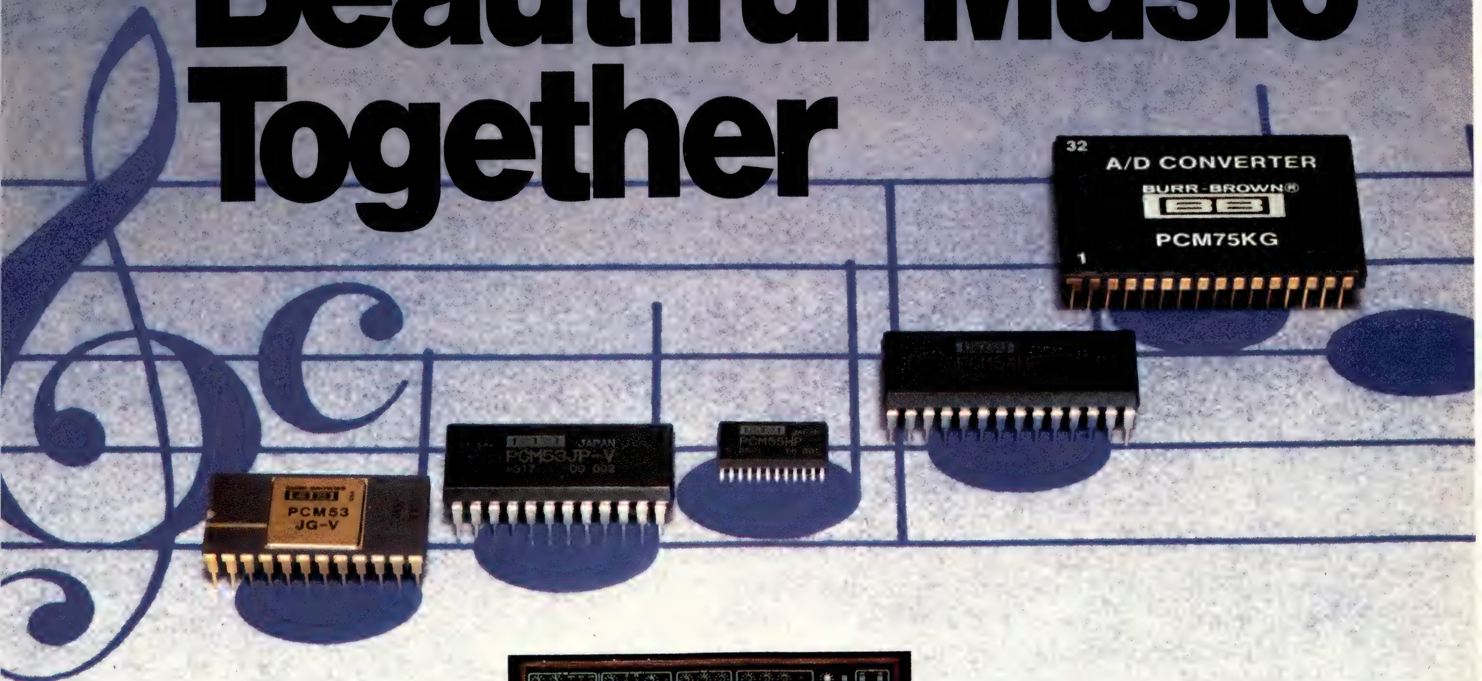

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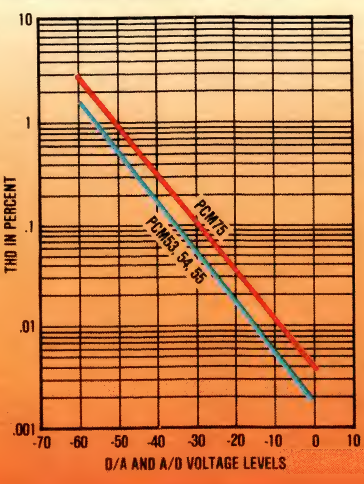

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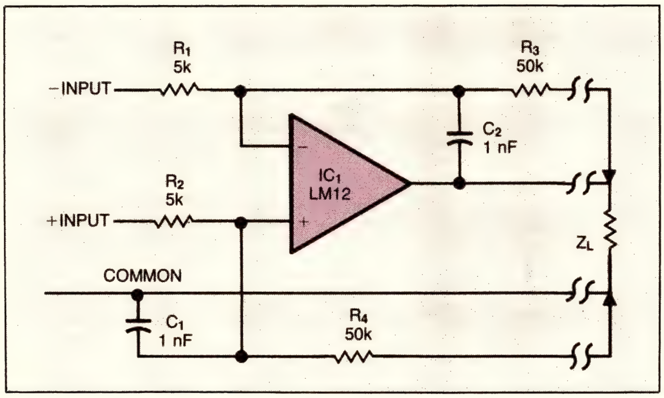

Fig 15—Remote sensing via wires *that are independent of the main power cables allows the op amp to correct for dc drops in this configuration.*

tor values in the circuit depend upon the cable delay.

To configure the circuit for a single-ended input, you'd strap the unused input terminal in the schematic to the common. To avoid second-order errors (eg, temperature drifts), you must make sure that the feedback resistors are reasonably matched. To avoid gain errors, you must make the feedback resistors' values sufficiently greater than the sense-line resistance.

Determining dissipation

You can easily determine how much power an op amp must dissipate when driving a resistive load at frequencies well below 10 Hz. Maximum dissipation occurs under high supply-line conditions, when the output level is one-half the supply voltage. The individual output transistors must be able to handle this power continuously at the maximum expected case temperature.

If ripple occurs on the supply bus, you can use the average supply value in worst-case calculations, as long as the peak power in the transistor doesn't exceed its maximum rating. For 120-Hz ripple, the IC's peak rating is 1.5 times its continuous power rating.

It's not so easy to establish the op amp's dissipation requirements when the amplifier delivers time-varying output signals, especially to reactive loads. You must take both peak- and continuous-dissipation ratings into account, and these ratings depend on the signal's waveform as well as the load's characteristics. When the op amp delivers a sine wave, you can easily determine the power in the output transistors. If the supply voltages are $\pm V_S$, the maximum average power dissipation of both output transistors is

$$P_{MAX} = \frac{2V_S^2}{\pi^2 Z_L \cos\theta}\ (\theta < 40°)$$

and

$$P_{MAX} = \frac{V_S^2}{2Z_L}\left[\frac{4}{\pi} - \cos\theta\right]\ (\theta \geq 40°),$$

where Z_L is the magnitude of the load impedance and θ is its phase angle. Maximum average dissipation occurs for a peak output swing, E_P, which is defined by

$$E_P = \frac{2V_S}{\pi\cos\theta}\left(\cos\theta > \frac{2V_S}{\pi V_P}\right)$$

or

$$E_P = V_P\left(\cos\theta \leq \frac{2V_S}{\pi V_P}\right),$$

where V_P is the maximum available output swing.

The instantaneous power dissipation is

$$P = \frac{E_P}{Z_L}\cos\omega t\left[V_S - E_P\cos(\omega t + \theta)\right].$$

For $E_P = V_S$, the power peak occurs for $\omega t = \frac{1}{3}(\pi - \theta)$. In practice, $E_P < V_S$, and you must find a numerical solution.

The instantaneous power dissipation over the conducting half-cycle of one output transistor is shown in **Fig 16.** Power dissipation is near zero during the other half-cycle. The output level is that resulting in maximum peak and average dissipation. The plots show dissipation for a resistive and a series RL load. The latter, which is characteristic of a 4Ω loudspeaker operating at a frequency below resonance, would be the worst-case condition in most audio applications. The peak dissipation of each transistor is about four times average. In ac applications, the peak ratings of the power transistor often limit the op amp's power.

The LM12's pulse thermal resistance is specified for constant-power pulse duration. Establishing an exact equivalency between constant-power pulses and those actually encountered is not easy. However, for sine waves, you can make reasonable estimates at any frequency by using the constant-power pulse amplitude defined by

$$P_{PK} \cong \frac{V_S^2}{2Z_L}\left[1 - \cos(\phi - \theta)\right],$$

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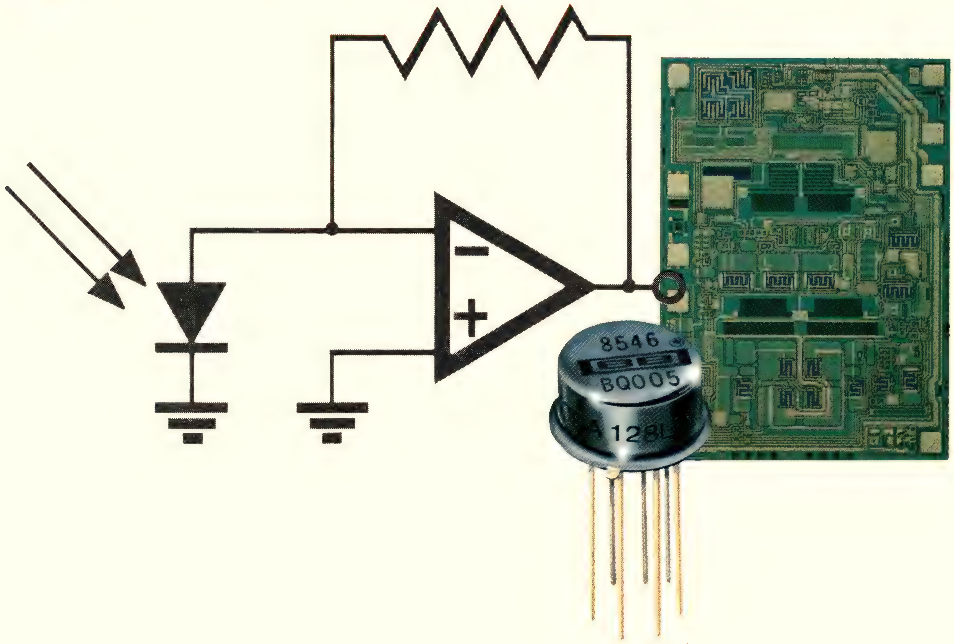

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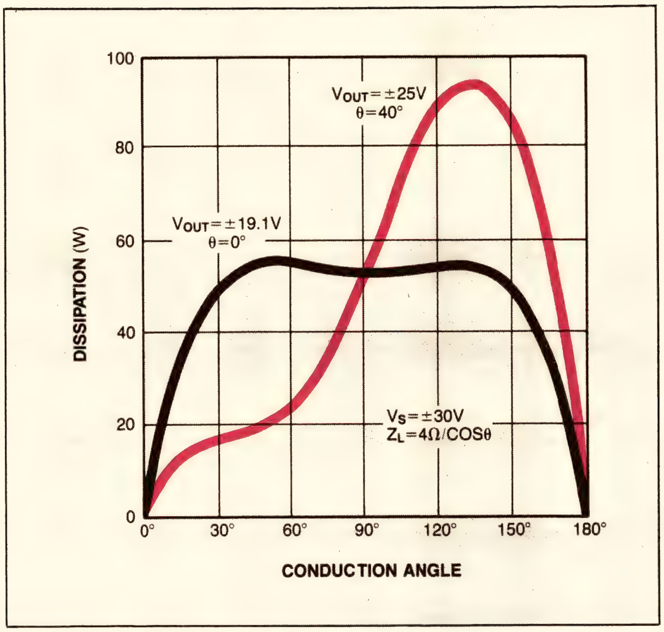

***Fig 16—The instantaneous power dissipation** in an LM12's output transistor is markedly different for inductive and resistive loads. The more peaked curve is the device's dissipation in the presence of an inductive load whose phase angle is 40°. (Curves courtesy Michael Widlar)*

where $\phi=60°$ and θ is the absolute value of the phase angle of Z_L. Equivalent pulse width is $t_{ON} \approx 0.4\tau$ for $\theta=0°$ and $t_{ON} \approx 0.2\tau$ for $\theta>20°$, where τ is the period of the output waveform.

For the LM12, you can actually measure the peak junction-temperature rise for any given waveform. To take this measurement, you raise the case temperature until the power-limiting function is activated. You then compute temperature rise from the measured case temperature, based on a power-limit temperature of 230°C.

Alternatively, you can determine the power-limit temperature directly by measuring the dc dissipation (at a collector-emitter voltage of 20V) required to activate the power-limiting mechanism. If you take this measurement over a range of case temperatures, you can plot the results and extrapolate the power-limit temperature. You can use this procedure to give the peak temperature rise as a function of frequency for an op amp driving a resistive load under conditions of worst-case dissipation. A sample plot appears in **Fig 17.**

To determine driver dissipation when the driver's load is a motor with a locked rotor, consider the motor as an inductor in series with a resistor. In slow-response servos, the maximum signal amplitude at frequencies where motor inductance is significant can be so small that you don't need to take motor inductance into account. In these situations, you can treat the motor as a simple, resistive load as long as the rotor speed is low enough that the back EMF is small in comparison with the supply voltage of the driver transistor.

A permanent-magnet motor can build up a back EMF that's equal to the output swing of the op amp driving the motor. When reversing this motor from full speed,

You can easily determine how much power an op amp must dissipate when driving a resistive load at frequencies well below 10 Hz.

the output drive transistor operates, initially, along a load line based on the motor's resistance and the total supply voltage. In the worst case, this load line will have to be within the continuous dissipation rating of the drive transistor, but in a typical system that operates dynamically, you may be able to take advantage of the higher pulse ratings. If the system's response is fast, the motor inductance can cause stress to the driver's output transistors in addition to the stress arising from resistive effects.

During steady-state operation, you can easily determine the pass transistor's dissipation in a voltage regulator. Maximum continuous dissipation occurs under the conditions of high line voltage and maximum load current. As mentioned, you can average ripple voltage as long as you don't exceed the IC's peak ratings; however, you must use a higher average voltage to ensure that the pass transistor doesn't saturate at the ripple minimum.

Determining the pass transistor's dissipation during start-up can be a more complex task. If the input voltage increases slowly enough that the regulator doesn't go into current-limit mode while charging output capacitance, no problems arise. However, if the input voltage increases too quickly, or if the regulator must provide automatic restart in recovering from

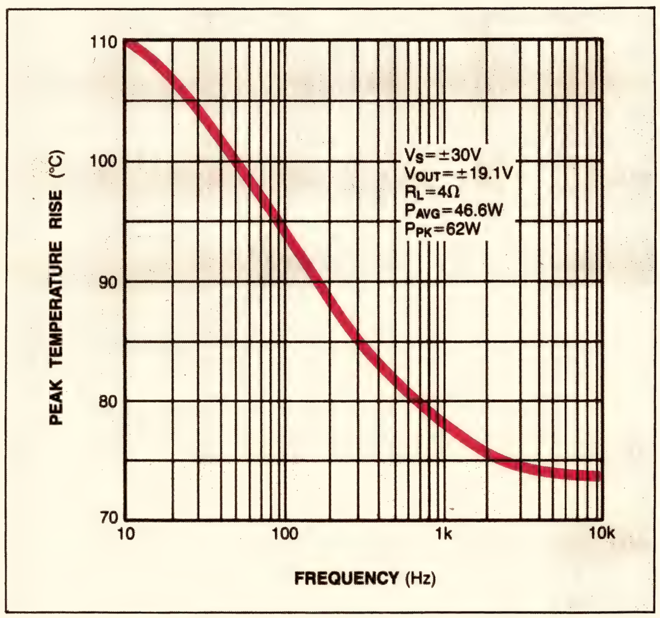

***Fig 17—The peak junction-temperature rise** for the LM12's output transistors is a strong function of frequency. For this curve, the LM12 drives a resistive load under the condition of worst-case power dissipation.*

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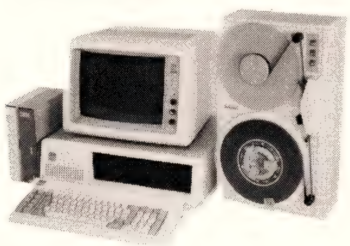

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CIRCLE NO 99

overloads, you must take load capacitance and load characteristics into account.

When fast-rising input voltages are present, you can't be absolutely sure that automatic restart or start-up will take place unless the continuous-dissipation rating of the pass transistor is adequate: The transistor must be able to supply the load current continuously at all voltages below the regulated output voltage. With regard to start-up, the LM12 performs much better than do IC regulators using foldback current limiting, especially if high-line input voltages are above 20V.

You can establish thermal-design margins by determining how far you can push the LM12 beyond nominal worst-case conditions before its power-limiting mechanism is activated. You can apply this extra stress by increasing case temperature, supply voltage, or output loading.

When you raise case temperature under worst-case electrical conditions, you obtain results that you can easily interpret in terms of thermal-design margins. If you must raise the case temperature (as measured at the center of the bottom of the package) 50°C above the maximum design value to activate power limiting, the worst-case, peak junction temperature is 180°C, or 50°C below the power-limit temperature. If you use this technique, it's important that you keep the case temperature below 140°C. At 150°C, the case-temperature limit engages, shutting the IC down completely. **EDN**

Reference

1. Widlar, Robert, and Mineo Yamatake, "Overcome electrical, thermal problems in high-power op amps," *EDN*, May 15, 1986, pg 117.

Authors' biographies

Robert Widlar is a freelance linear-IC design consultant for National Semiconductor Corp (Santa Clara, CA). Designer of the legendary 702 and 709 monolithic op amps in a previous position at Fairchild Semiconductor (Mountain View, CA), Bob now lives in Puerto Vallarta, Mexico.

Mineo Yamatake has designed linear ICs at National Semiconductor (Santa Clara, CA) for the past 19 years. Before joining the company, he performed the same function at Fairchild Semiconductor (Mountain View, CA). Mineo's spare-time pursuits include fishing and mountain biking.

Article Interest Quotient (Circle One)
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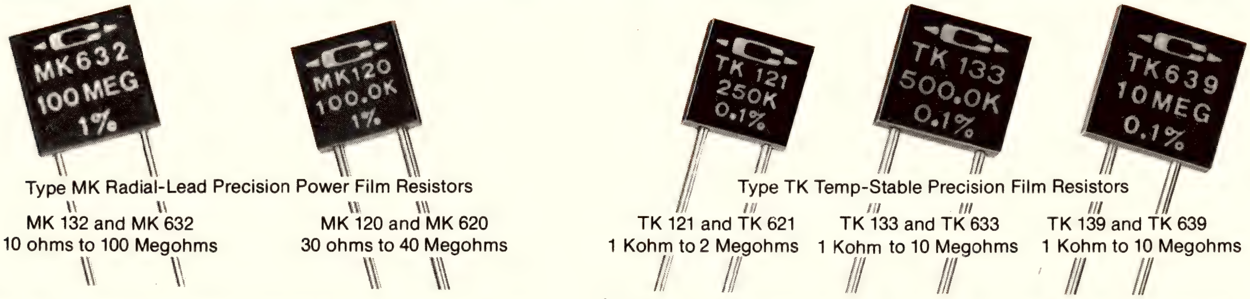
Radial-Lead Precision Film Resistors from Caddock combine high values and tight tolerances with a choice of two high-power densities or three low TCs.



Type MK Radial-Lead Precision Power Film Resistors

MK 132 and MK 632
10 ohms to 100 Megohms

MK 120 and MK 620
30 ohms to 40 Megohms

Type TK Temp-Stable Precision Film Resistors

TK 121 and TK 621
1 Kohm to 2 Megohms

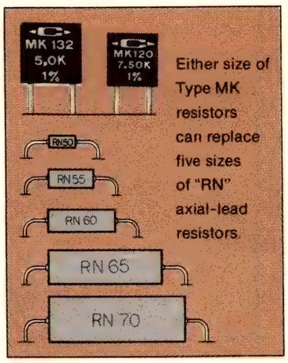
TK 133 and TK 633
1 Kohm to 10 Megohms

TK 139 and TK 639
1 Kohm to 10 Megohms

Type MK Radial-Lead Precision Power Film Resistors utilize Caddock's Micronox® resistance films to achieve high power density and an extended range of resistance values:

Available in two rectangular radial-lead packages that include values as high as 100 Megohms, these high-density film resistors permit electronic circuit designers to optimize packaging and PC board layouts with resistors that meet all these specifications:

	MK 120	MK 620	MK 132	MK 632
• Resistance Range	30 ohms to 2 Megohms	2.1 Megohms to 40 Megohms	10 ohms to 5 Megohms	5.1 Megohms to 100 Megohms
• Resistance Tolerance	±1.0% is standard, to ±0.1% on special order, depending on value and model.			
• Wattage	0.5 Watt	——	0.75 Watt	——
• Voltage	200 V	200 V	400 V	400 V
• Temperature Coefficient	50 PPM/°C	80 PPM/°C	50 PPM/°C	80 PPM/°C
	Temp Range: −15°C to +105°C, ref. +25°C.			
• Package Size	.250" square, .100" thick		.300" square, .100" thick	



These full-size photos comparing the Type MK resistors to "RN" style axial-lead resistors show that the largest Type MK, which is rated at 3/4 watt, requires less board space than the 1/20 watt "RN 50".

And within their voltage ratings, both sizes of Type MK resistors can replace five sizes of "RN" resistors, including the 1/2 watt "RN 70" which requires 10 times the board space of the MK 132!

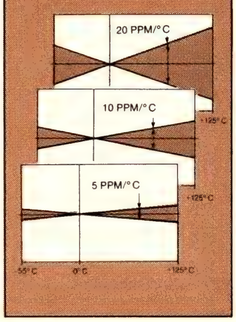
This combination of higher power rating and smaller size can also lower procurement costs by replacing many sizes of axial-lead resistors with Type MK resistors that have a 'standard' size and mounting dimensions.

Type TK Temp-Stable Precision Film Resistors with Caddock's Tetrinox® resistance films combine a choice of TCs of 5, 10 or 20 PPM/°C, a wide resistance range and tight tolerances.

Type TK Temp-Stable Precision Film Resistors provide a combination of performance advantages that are unique in a miniature resistive component:

- **Three Standard Temperature Coefficients:** 5 PPM/°C, 10 PPM/°C or 20 PPM/°C over the temperature range from −55°C to +125°C. (+105°C max. for values above 500 Kohms or 1.5 Megohms, depending upon model.)
- **Resistance Range:** 1 Kohm to 10 Megohms.
- **Precision Tolerances:** ±1.0% is standard, and tolerances as close as ±0.05% are available on special order.
- **Load Life Stability:** 0.05% maximum ΔR after 2000 hours at full power at +125°C. (0.2% max. for values above 500 Kohms or 1.5 Megohms, depending upon model.)
- **Two Power Ratings:** .2 watt and .3 watt.

Each model of Type TK resistors has three TC options:



The Model TK 121, TK 133 and TK 139 precision film resistors have demonstrated performance which meets the requirements of Mil-R-55182/9 for thermal shock, moisture resistance, shock and vibration, dielectric withstanding voltage and low temperature operation.

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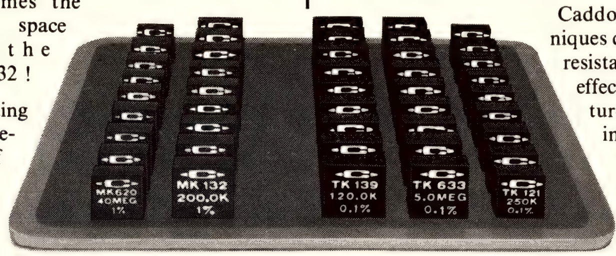

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This programmable DAC conforms to RS170A standards with pixel rates up to 50 MHz, in a 28 pin package.

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The Hitachi Advanced CRT Controller (ACRTC)

Now you can generate sophisticated graphics easier than you ever thought possible.

The Hitachi HD63484 ACRTC is the next generation of peripheral LSI. It embodies Hitachi's 2-micron CMOS technology to integrate all CRT and graphics control functions on one chip. This *all*-CMOS design has three on-board processors to relieve the system's CPU of many time-consuming supervision tasks. On-board intelligence means your design will have a lower chip count, more reliability, and will actually cost less at system level.

Naturally, all-CMOS construction means less power draw, power dissipation, and less sensitivity to environmental problems, making the ACRTC ideal for portable and battery powered applications.

On-chip intelligence eliminates tedious number crunching

High level integration has come of age: the ACRTC executes 38 *high-level* commands. There are 23 graphic drawing commands, including LINE, RECTANGLE, ELLIPSE, POLYGON, CIRCLE, PAINT, and COPY. Programming and design are much easier because you don't have to compute command parameters, and address translation is done in *hardware*. This means you get into production more quickly and it's easier to introduce modifications.

The ACRTC has eight conditional drawing functions, drawing area control via hardware clipping and hitting, and an optimized CPU interface that works with 8 or 16-bit architecture. It's truly a *universal* peripheral.

On-chip speed and detail will unlock your potential

The images you will create will be truly remarkable. Just imagine: ▫ 65,536 different colors. ▫ 4096 x 4096 bit-mapped graphics displays. ▫ 256 line x 256 character displays. ▫ Three fully programmable horizontal split screens. ▫ Windowing. ▫ Independent horizontal and vertical smooth scroll for all screens. ▫ One to 16 zoom feature with independent control of X and Y zoom factors.

These visual fireworks take place at speeds of up to two million *logical* pixels per second, for mono-

Dazzling images

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Compare Advanced CRT Controller Detailed Specifications

Parameter	Hitachi ACRTC	NEC GDC
Process Technology	2-micron VLSI CMOS	NMOS
Command Structure	38 high-level commands	20
Graphic Drawing Commands	23—including PAINT, PATTERN, COPY, plus shapes	No PAINT or COPY
Resolution Bit-mapped Graphics Alphanumeric	 4K x 4K 256 line x 256 char.	 2K x 2K 100 line x 256 char.
Drawing Speed	2 million pixels/sec. (at 8MHz clock)	10% of ACRTC speed for color 2% of ACRTC speed for graphic data movement
XY Address Translation	On-board hardware	Via host MPU
Color Logic	On-board, variable pixel bit length, 64K colors	None
Video Attributes	8 user definable	Need external PIO
Cursor	2, implemented with on-board hardware, 3 cursor modes	1 cursor, 1 mode
Pattern RAM	32 bytes	16 bytes
Frame Buffer Width	128 bits	32 bits
Video Bit Rate	>500MHz	80MHz
Clipping/Hitting	On-board hardware	Via host MPU
Windowing	On-board hardware	No hardware window
Host Interface FIFO	**Separate** 16 byte Read and Write FIFOs	Shared 16 byte Read and Write FIFOs
Host Bus Interface	8 or 16 bit	8 bit only
Maximum Clock Frequency	8MHz	5MHz
Power Consumption	400mW max.	1.35W max.
Packaging	64-pin plastic DIP, or PLCC*	Not Available

MNEMONIC	CONTENT	EXECUTION	DRAWING* SPEED
ALINE X, Y	ABSOLUTE LINE	CP (X, Y)	0.5
RRCT DX, DY	RELATIVE RECTANGLE	CP DX DY	0.5
CRCL R	CIRCLE	R CP	1
AGCP Xs, Ys, X, Y	ABSOLUTE GRAPHIC COPY	(Xs, Ys) CP (X, Y)	0.75
PAINT	PAINT	CP	2.25

CP: CURRENT POINTER

*μsec/pixel (MONOCHROME 65536 colour) at 8MHz Clock.

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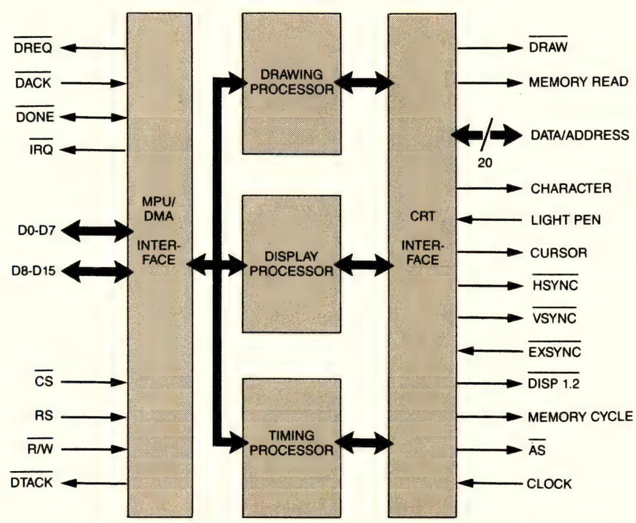

ACRTC ARCHITECTURE

This panda was drawn using the commands: LINE, ARC, ELLIPSE ARC, and PAINT. The program was written in less than 4 hours, using only 98 program steps.

*PLCC version available 3rd Quarter, 1985.

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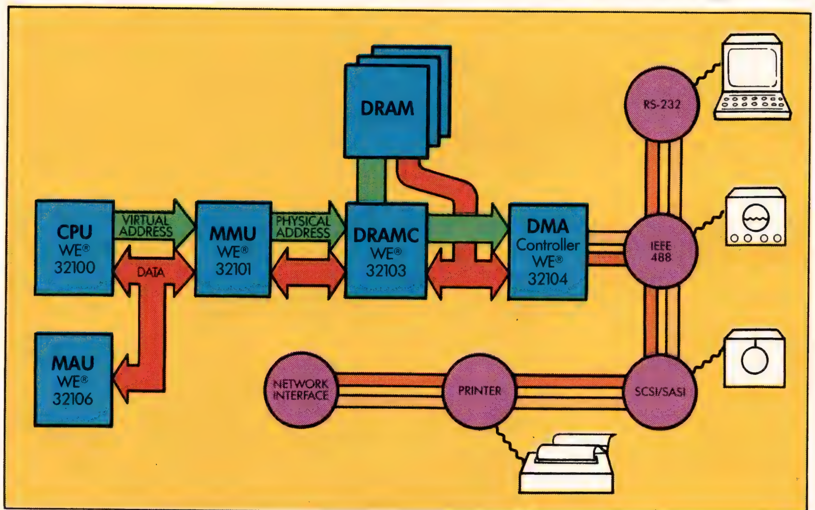

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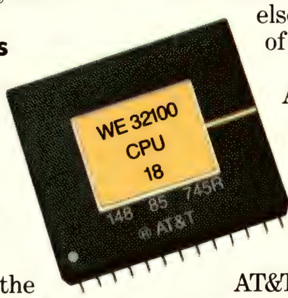

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CIRCLE NO 102

OCCASIONALLY, EVERYONE WISHES HE HAD ANOTHER SHOT AT HIS DESIGN.

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CIRCLE NO 103

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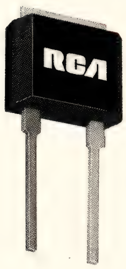

A breakthrough in surge protection.

Now there is something new in the world of surge protection. Surgectors are unlike zeners, MOVs, carbon arrestors or gas discharge devices.

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How Surgectors work.

Surgectors are monolithic structures integrating a zener diode and an SCR into one reliable, cost-effective device.

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SGT06U13	2-terminal	60V	.62
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SGT23B13	bi-directional	230V	.99
SGT10S10	3-terminal	100V	.72

Surgector vs. zener and MOV.

Surgectors are as fast as zener diodes (<1ns response time) yet can handle ten times as much energy. At breakdown voltage, Surgectors are two orders of magnitude lower in impedance than zeners (0.1 ohm vs. 10 ohms).

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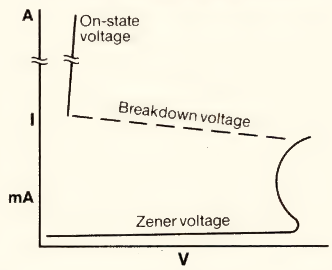
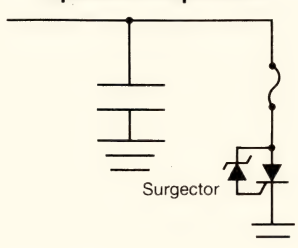
Typical Surgector voltage-current characteristics.



Surgectors are much faster than gas discharge tubes or carbon arrestors, but can carry less surge current. The transient peak current capability of the Surgector is 300A for 1μs x 2μs pulse and 75A for a 10μs x 1000μs pulse. Like other surge protectors, Surgectors will eventually fail if pushed beyond specifications. But Surgectors normally fail shorted, rather than open. And even shorted Surgectors protect expensive components. Only beyond triple the rated surge current will the Surgector blow open.

Typical protection for expensive components.



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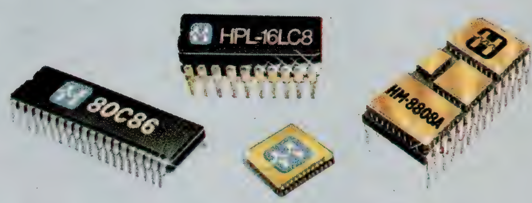

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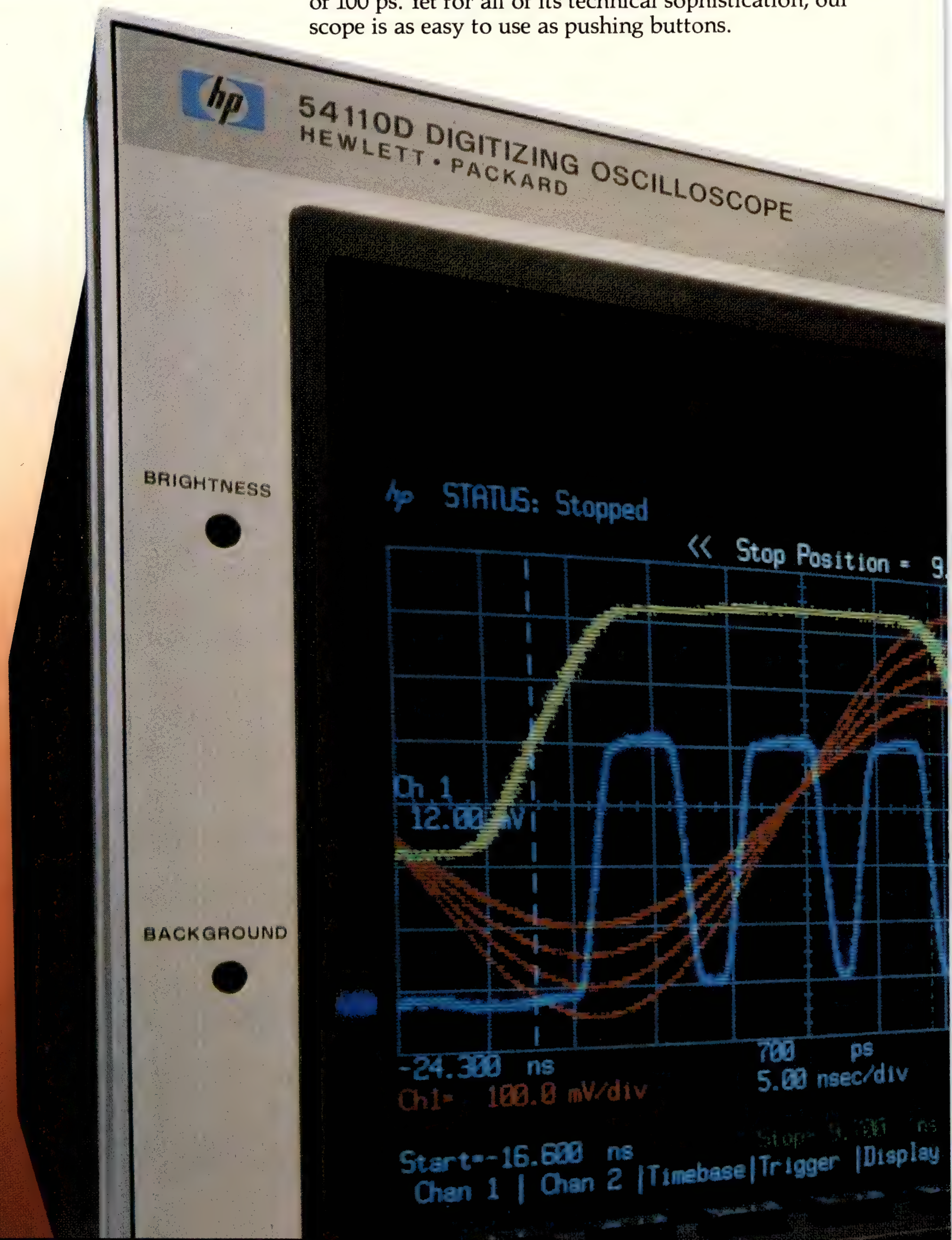

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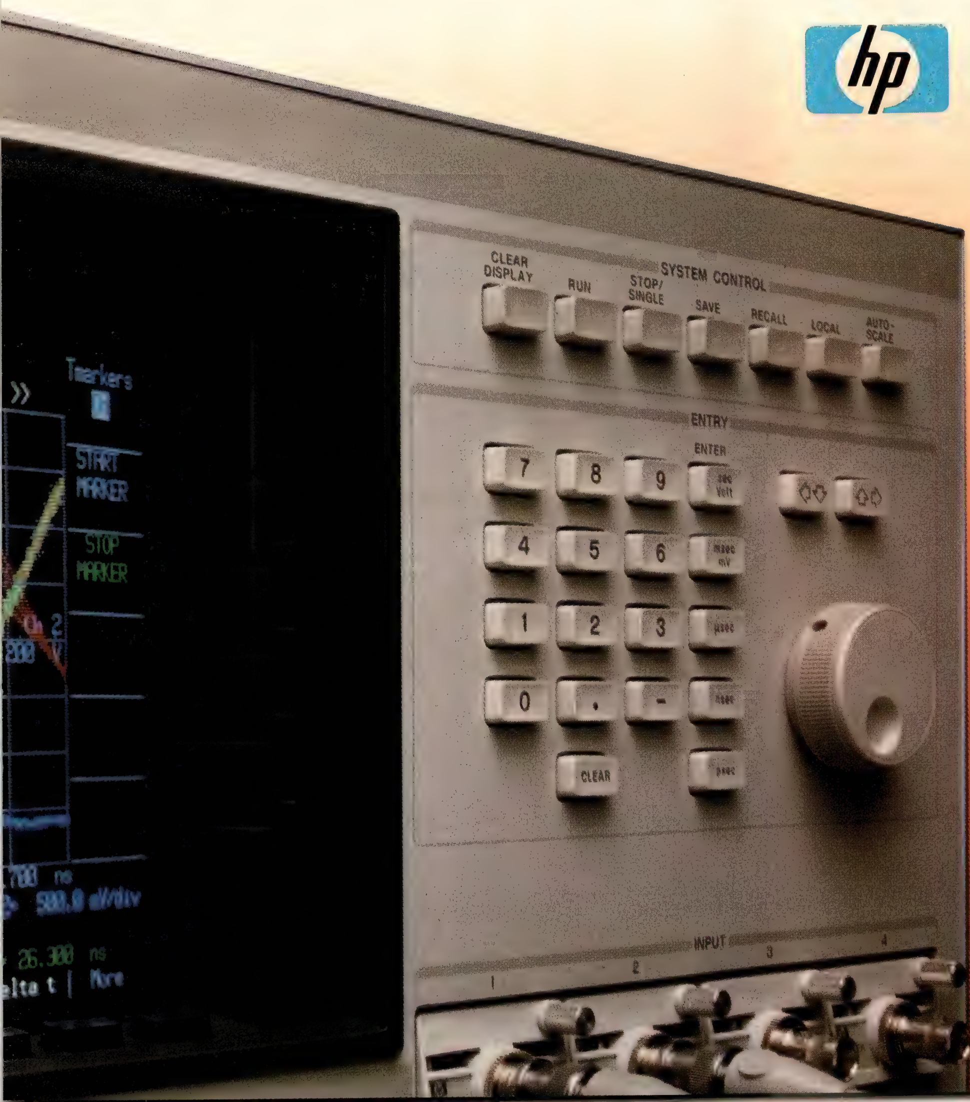

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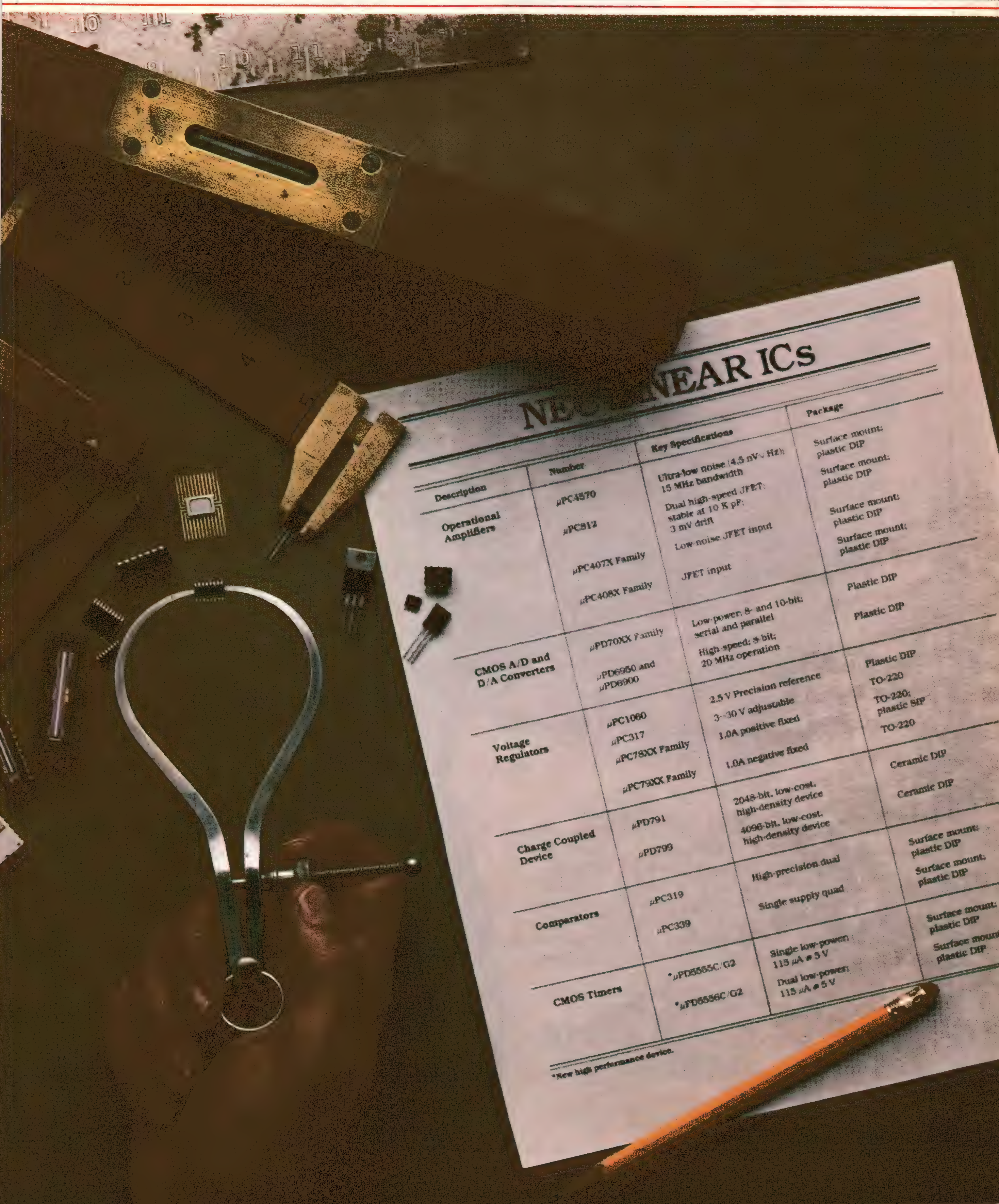

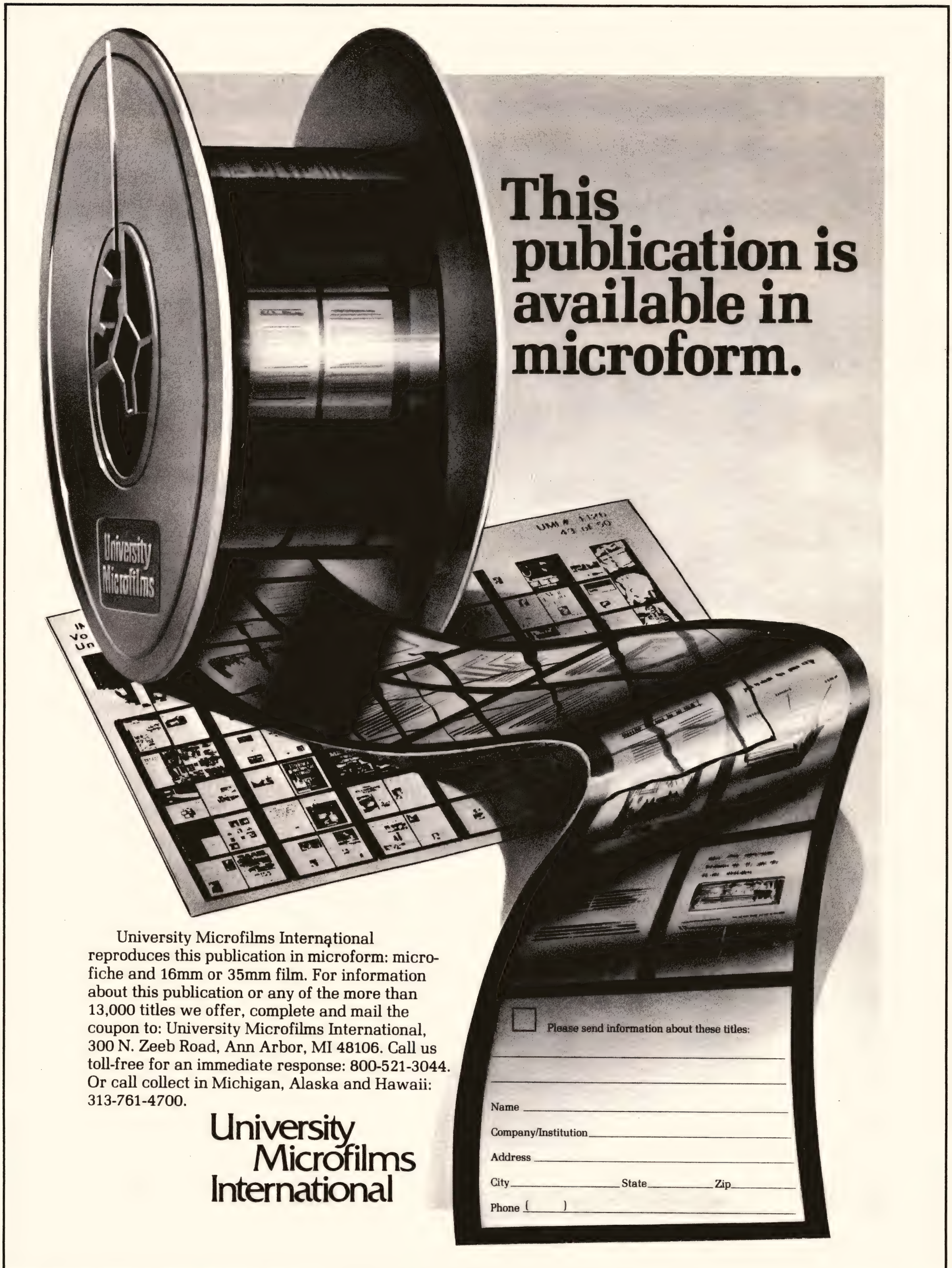
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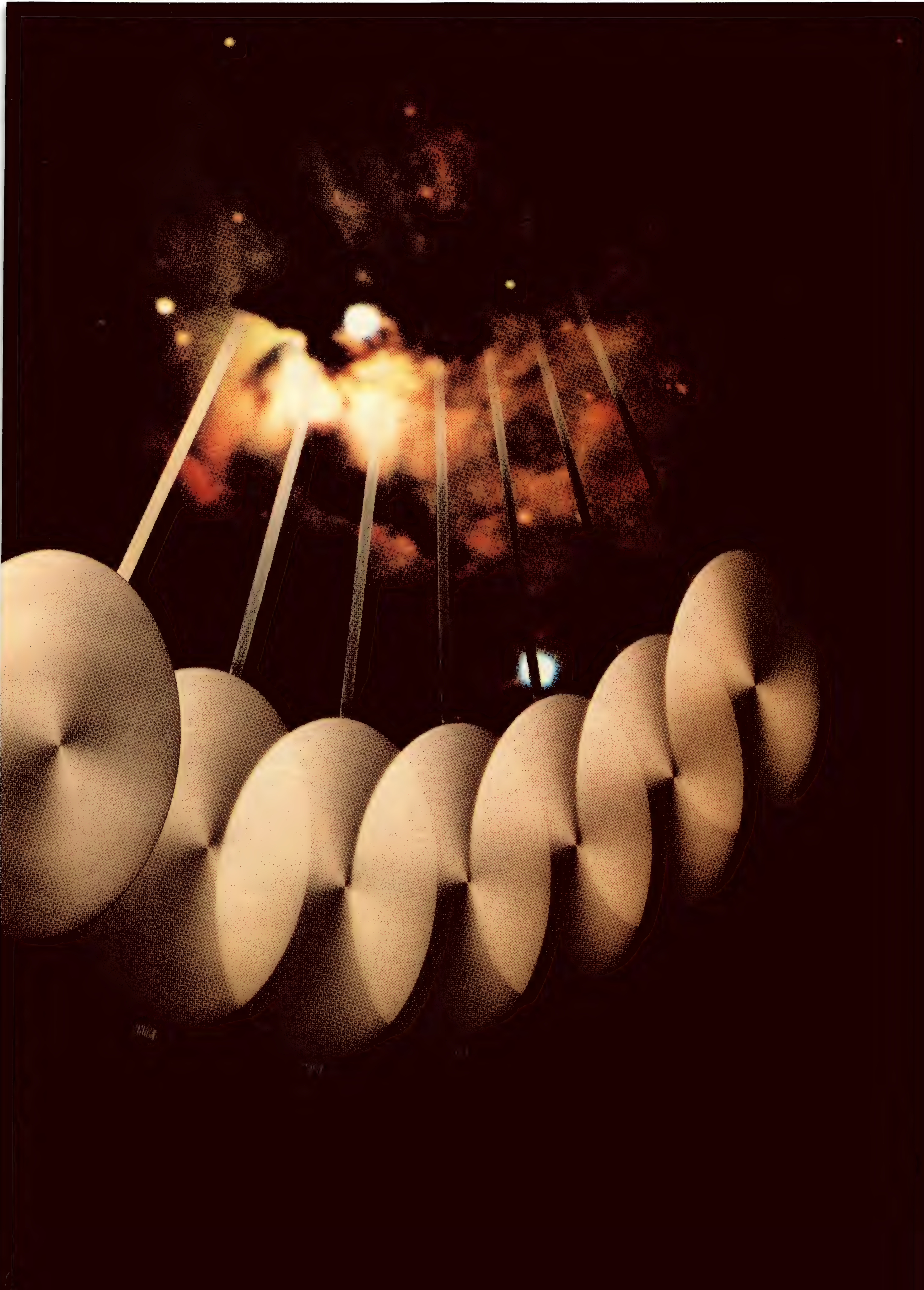

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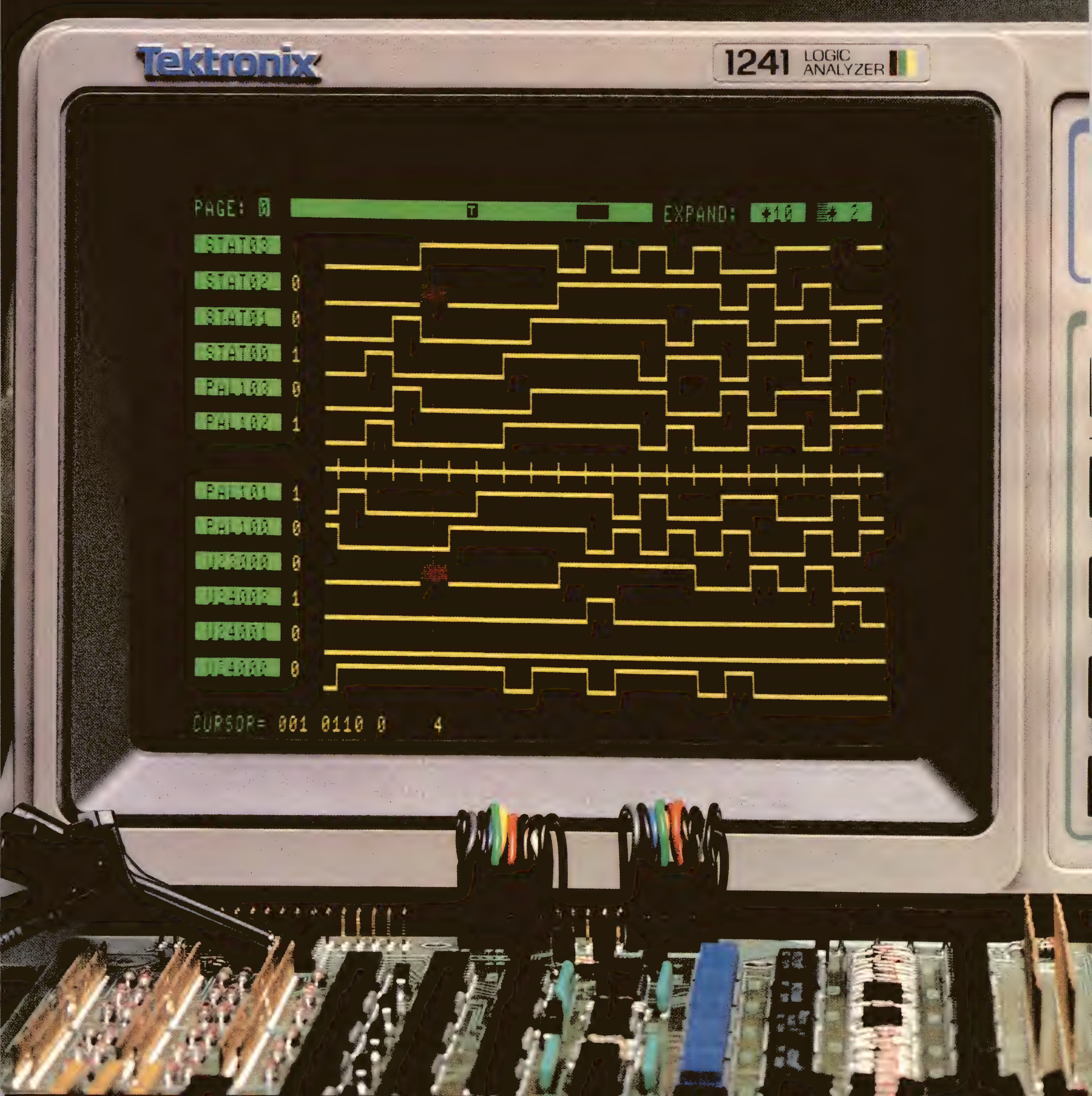

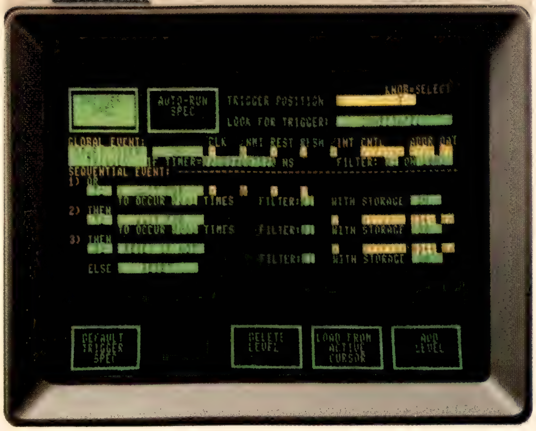

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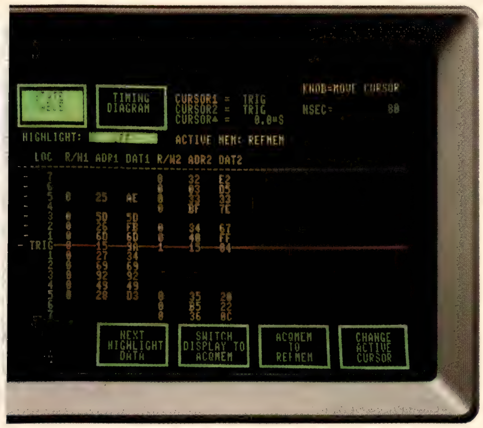

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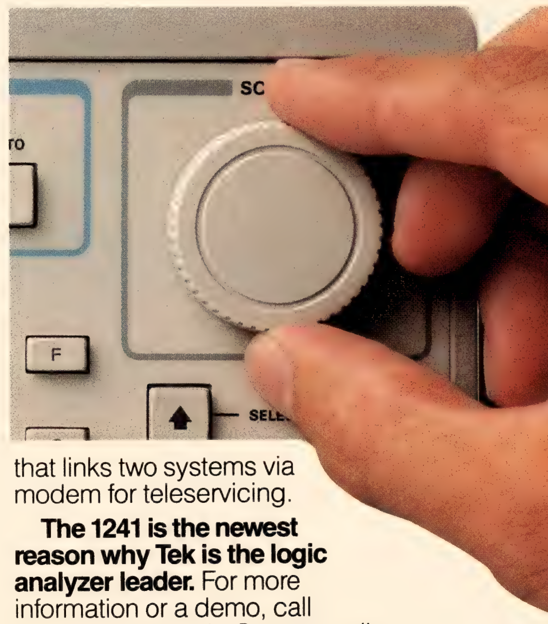

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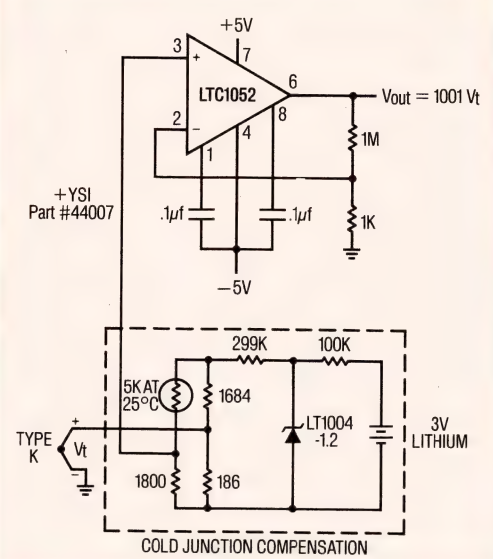
Thermocouple Amplifier with Cold Junction Compensation



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CIRCLE NO 110

EDITED BY TARLTON FLEMING

Simple circuit tests twisted-pair cables

Mark D Braunstein
Contel Information Systems, Fairfax, Va

Using the system shown in **Fig 1,** you can quickly test a cable containing twisted-wire pairs and detect open or reversed pairs, shorted pairs, and shorts between unrelated pairs. The tester consists of an active test set that plugs into one end of the cable, and a passive terminator that plugs into the other end. (An RS-449 cable is used as an example.)

A battery or a dc supply delivers 15 to 24V to the test set. The voltage regulator (IC_1) is connected as a current regulator to supply a nominal 25 mA to the LED strings at each end of the cable. The cable in this example contains eight twisted pairs, and for a good cable, all eight LEDs in the test set (D_A through D_H, which are series-connected segments of a bar-graph display) and all eight LEDs in the terminator (D_1 through D_8) will light. If a twisted pair is open or reversed, the corresponding LED on the terminator will be extinguished; if a pair is shorted, corresponding LEDs at both ends will be extinguished; and if any two unrelated wires of different pairs are shorted, all intervening LEDs in the strings at both ends will be extinguished. For example, if pins 4 and 6 are shorted, LEDs D_A, D_B, D_1, and D_2 will not light.

You can add a heat sink to the IC_1 regulator as a safety precaution, but normal tester operation is well within the regulator's power-dissipation limits. Even with many shorted pairs, a dissipation of 700 mW would cause no more than a 60°C junction temperature, and the IC is guaranteed to turn itself off at 160°C. The complete tester costs less than $50 to build. **EDN**

To Vote For This Design, Circle No 750

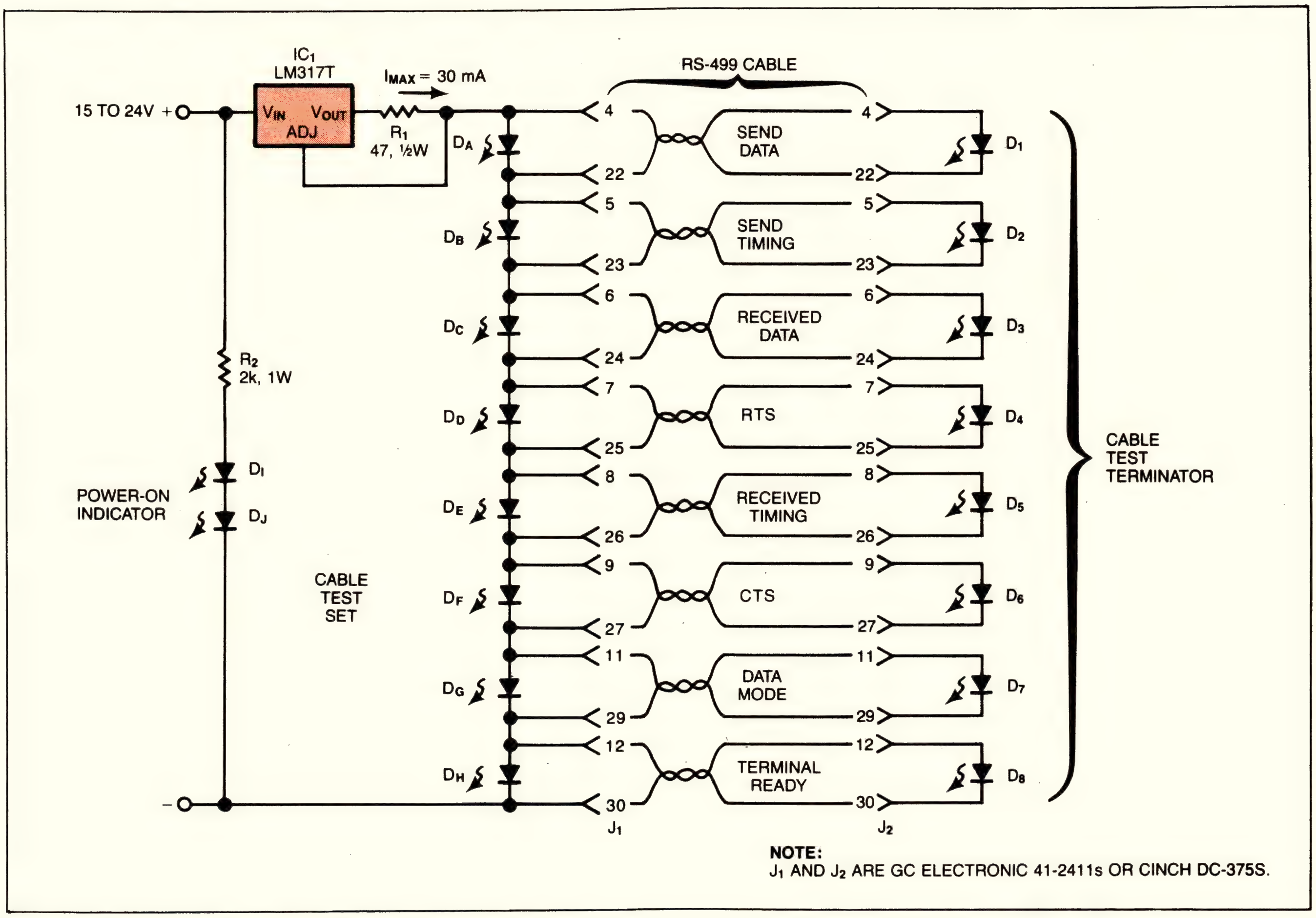

Fig 1—By driving two LED strings from a common current source, *you can quickly check a cable of twisted-pair wires for short circuits, open circuits, and pair-to-pair shorts.*

Memory-driver chip controls MOSFET gate

Mangala A Morey
Picker International, Mayfield Village, OH

Motor-control circuits that use pulse-width modulation (PWM) also require a power-amplifier stage, such as the "H" configuration shown in **Fig 1.** In that circuit, turning on transistors Q_1 and Q_4 would rotate the motor in one direction; turning on Q_2 and Q_3 would rotate the motor in the opposite direction.

Traditionally, properly biased transistors are used to drive the power MOSFETs in such circuits. However, fast switching times (20 to 25 nsec typ) and 24V output capability make the DS75325 memory driver (IC_1 in **Fig 1**) a suitable alternative for driving the MOSFETs' gates. You connect the PWM signal to the S1 strobe input; the resulting pulses at W and X have the same duration as those at S1 but swing from 0 to 15V, as required by many power MOSFETs. Inputs A and B serve as logic-enable inputs. The open-emitter outputs W and X require load resistors (R_3 and R_4); these resistors also help limit current to the MOSFET gates.

Catch diodes D_3 and D_4 absorb the reverse-current spikes that occur when the motor changes direction, and the MOSFETs contain internal diodes for the same purpose. Current-limiting resistors R_1 and R_2 are chosen according to the stall current for the motor you are using. Furthermore, zener diodes D_1 and D_2 protect Q_1 and Q_2 in the event of a short in the motor. EDN

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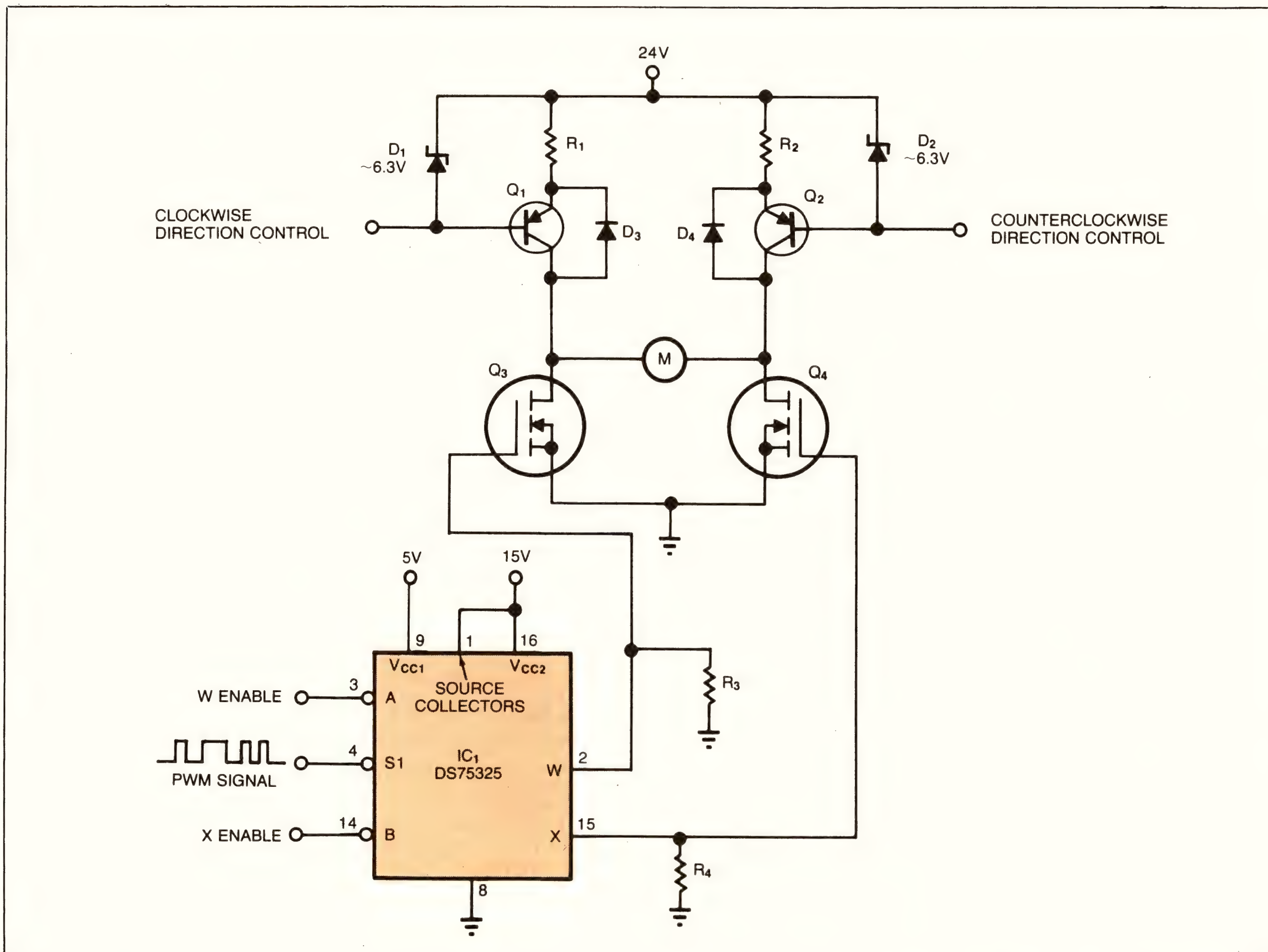

Fig 1—A memory-driver IC provides the interface *between a motor controller's PWM signal and a MOSFET power-amplifier stage.*

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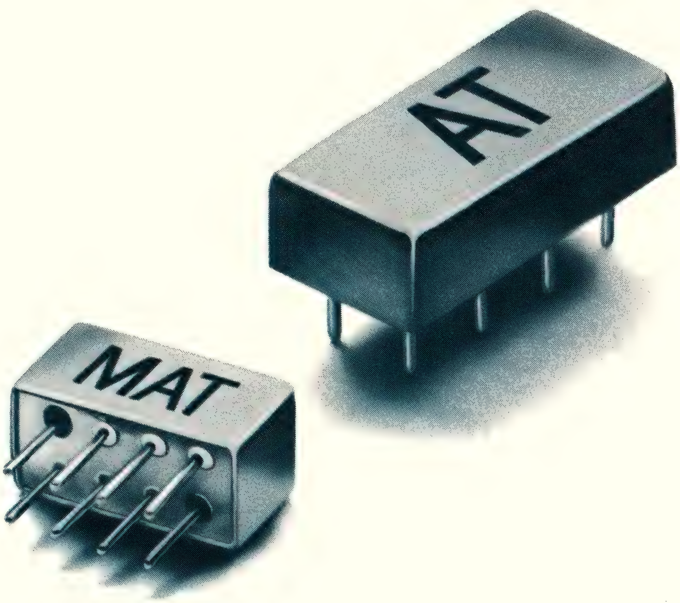

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AT-7	MAT-7	7
AT-8	MAT-8	8
AT-9	MAT-9	9
AT-10■	MAT-10	10
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CIRCLE NO 111

C 81 REV. B

Connect PROM as a ring counter

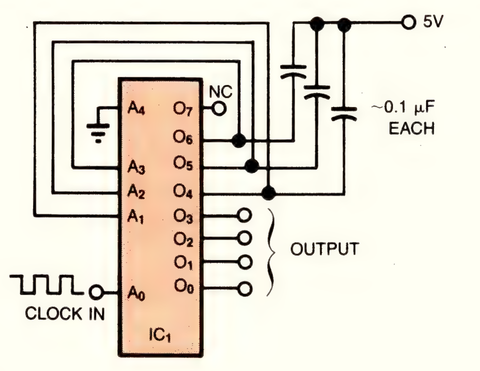
Tan Tran and Tien Tran
Houston, TX

By feeding certain output lines back to the address inputs, you can force a PROM to generate a repeating output sequence. In **Fig 1a**'s circuit, for example, a 32×8-bit device produces a 4-line sequence. To prevent racing, the PROM contents **(Fig 1b)** are arranged so each consecutive address causes only one bit change at most in the output (O_3 through O_0) and the feedback (O_6 through O_4). To ensure proper operation, you must delay the feedback by adding the three 0.1-μF capacitors. *(Ed Note: You may need lower-value capacitors for a fast clock rate.)* Also, the clock period must exceed the PROM's access time to achieve stable output data.

The feedback lines are high when power is applied. While the clock is high, the circuit is in a stable reset state because the feedback outputs are not in conflict with the capacitor voltages. The output is 0100. When the clock (address line A_0) goes low, output O_4 begins to pull A_1 low, eventually producing the next stable state corresponding to address 1100. The resulting code sequence and output waveforms are shown in **Fig 2.**

EDN

To Vote For This Design, Circle No 749



(a) NOTE: IC_1 IS A 74S288 OR EQUIVALENT, OR A2716 EPROM.

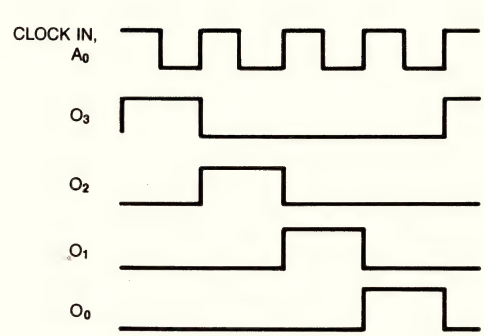
(b) TYPICAL SEQUENCE:

	A_3	A_2	A_1	A_0	O_7	O_6	O_5	O_4	O_3	O_2	O_1	O_0
STABLE	1	1	1	1	0	1	1	1	0	1	0	0
	1	1	1	0	0	1	1	0	0	1	0	0
STABLE	1	1	0	0	0	1	1	0	0	1	0	0
	1	1	0	1	0	0	1	0	1	0	0	0
STABLE	0	1	0	1	0	0	1	0	1	0	0	0
	0	1	0	0	0	0	0	0	1	0	0	0
STABLE	0	0	0	0	0	0	0	0	1	0	0	0
	0	0	0	1	0	1	0	0	0	0	0	1
STABLE	1	0	0	1	0	1	0	0	0	0	0	1
	1	0	0	0	0	1	0	1	0	0	0	1
STABLE	1	0	1	0	0	1	0	1	0	0	0	1
	1	0	1	1	0	0	0	1	0	0	1	0
STABLE	0	0	1	1	0	0	0	1	0	0	1	0
	0	0	1	0	0	0	1	1	0	0	1	0
STABLE	0	1	1	0	0	0	1	1	0	0	1	0
	0	1	1	1	0	1	1	1	0	1	0	0
STABLE	1	1	1	1	0	1	1	1	0	1	0	0

Fig 1—This 32×8-bit PROM circuit (a) and its contents (b) produce a repeating sequence when driven by the clock signal.

(a)

				CLK	PROM CONTENTS							
					NC	FEEDBACK			OUTPUTS			
	A_3	A_2	A_1	A_0	O_7	O_6	O_5	O_4	O_3	O_2	O_1	O_0
	0	0	0	0	0	0	0	0	1	0	0	0
	0	0	0	1	0	1	0	0	0	0	0	1
	0	0	1	0	0	0	1	1	0	0	1	0
	0	0	1	1	0	0	0	1	0	0	1	0
	0	1	0	0	0	0	0	0	1	0	0	0
	0	1	0	1	0	0	1	0	1	0	0	0
	0	1	1	0	0	0	1	1	0	0	1	0
	0	1	1	1	0	1	1	1	0	1	0	0
	1	0	0	0	0	1	0	1	0	0	0	1
	1	0	0	1	0	1	0	0	0	0	0	1
	1	0	1	0	0	1	0	1	0	0	0	1
	1	0	1	1	0	0	0	1	0	0	1	0
	1	1	0	0	0	1	1	0	0	1	0	0
	1	1	0	1	0	0	1	0	1	0	0	0
	1	1	1	0	0	1	1	0	0	1	0	0
RESET STATE	1	1	1	1	0	1	1	1	0	1	0	0



(b)

Fig 2—Operation of Fig 1a's circuit produces the output-code sequence in a, which you observe as the waveforms shown in b.

DAC lends digital control to phase-shifter

Robert A Pease
National Semiconductor Corp, Santa Clara, CA

It's well known that, using a single op amp, you can build an all-pass phase shifter that provides unity gain and variable phase over the approximate range of 4° to 176° (**Fig 1**). To provide digital control, though, you can't easily replace resistor R_1 with a D/A converter, because the resistor is not referenced to ground.

Fig 2's circuit offers the same phase-shifter function plus digital control of phase with 10-bit resolution. The op amp (IC_1) is connected as an adder-subtractor that forces V_3 to equal V_4+V_{IN}. This action in turn impresses V_{IN} between the input and output of the integrator formed by op amp IC_2, capacitor C, and the resistance (R_{DAC}) of the D/A converter (IC_4). The integrator thus resolves V_{IN} into two orthogonal vectors, because the phase of V_3 and V_5 must differ by 90°. V_{OUT} is the sum of V_3 and V_5, yielding the same transfer function as the circuit shown in **Fig 1**,

$$V_{OUT} = V_{IN}\left(\frac{1 - pRC}{1 + pRC}\right),$$

where p is the Laplacian operator d/dt.

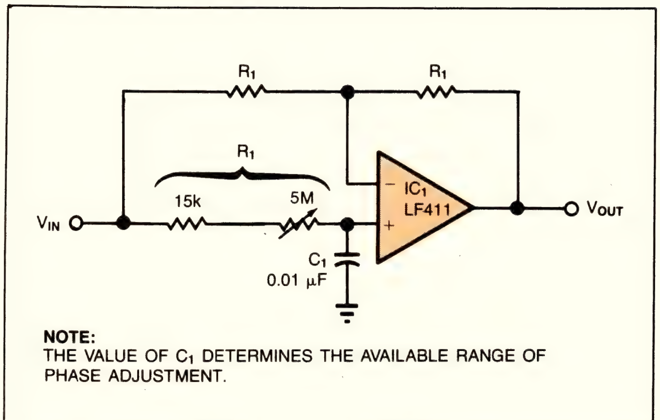


***Fig 1—This conventional all-pass phase-shifter** offers unity gain. By adjusting the potentiometer, you can vary the output phase from about 4° to about 176°.*

Because the D/A converter offers a high resistance when most bits are off, the input bias currents of IC_2 should be low to minimize the output offset; the op amp's offset voltage should be low for the same reason. You should add the offset-adjust potentiometer if IC_2's offset exceeds about 0.5 mV. For IC_1 and IC_3 you can use FET-input or bipolar op amps, although the higher slew rate of many FET-input types will let you handle

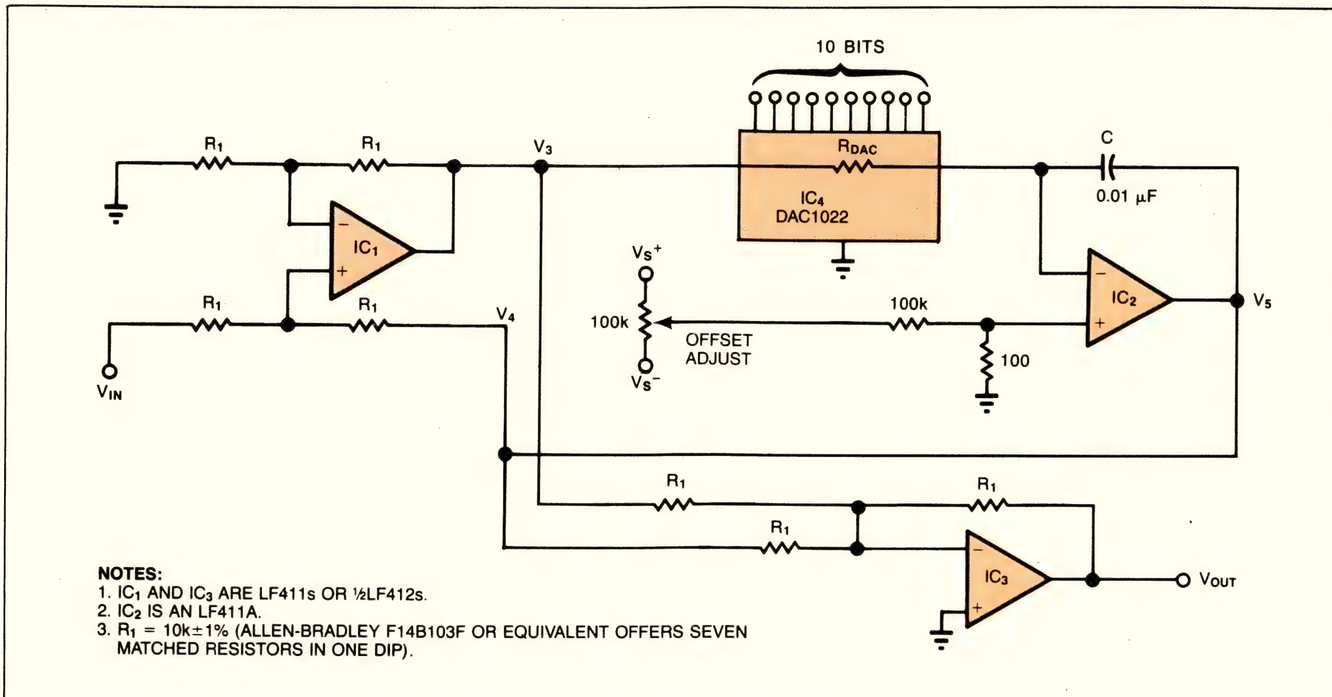


***Fig 2—Offering a transfer function similar to that of the circuit** shown in **Fig 1**, this circuit provides digital adjustment of phase with a resolution of 10 bits.*

faster signals.

With the components shown, **Fig 2**'s circuit covers a range of 4° to 176° or 0.1° to 89.9° at a fixed frequency, and it can maintain a fixed phase shift over a frequency range of about 1000:1. When covering the 0° to 90° range, for example, the circuit delivers a resolution of 0.11° per LSB or better, using a value of 0.01061 μF for C. For the range 0° to 180°, and using a value of 331.6 pF for C, the resolution is 3.58° per LSB. Alternatively, you could use a 12-bit D/A converter and a 166-pF capacitor to obtain 1.79° per LSB.

Applications for this circuit include the cancellation of unwanted phase shifts in control systems and the generation of odd sound effects in audio systems. By cascading two or three phase-shifters, you can "wobble" the phase controls to create special effects. **EDN**

To Vote For This Design, Circle No 746

Routine nests interrupts for the 8048

P R Apte
Digital Innovations Pvt Ltd, Vadodara, India

A program running on the 8048 8-bit single-chip microcomputer can be interrupted by the internal timer or through the interrupt input $\overline{\text{INT}}$, but the resulting service routines cannot be interrupted; program execution must encounter their return-from-interrupt (RETR) instructions before servicing the next interrupt. This limitation can cause problems: A power-down command requiring immediate attention, for example, must wait for completion of the current interrupt-service routine.

A few lines of code (see **Listing 1**) allow one service routine to interrupt another with lower priority. Execution of this higher-priority code temporarily increases the stack by one level, but the remaining stack is unaffected. The interrupt service routine INT1 of Program 1 first executes instructions that should not be interrupted, then jumps to a dummy call instruction, which puts the address of NEXT on top of the stack. Execution of the RETR instruction then passes control to NEXT, which allows the next interrupt to enter its service routine. (These interrupts should be enabled by software beforehand.) **EDN**

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LISTING 1

```
ISIS-II 8048/8049 CROSS-ASSEMBLER, V1.0

LOCN  OBJ     CYBY   SOURCE STATEMENT

0000                 ;****************************************
0000                 ;                PROGRAM-1
0000                 ;****************************************
0000                 ;
0000                 ;        INTERRUPT SERVICE ROUTINE-1
0000                 ;
0000                 ;****************************************
0000                 ; INT1:    ————————
0000                 ;          ————————
0000                 ;          ————————
0000                 ;  ENABLE INTERRUPTS
0000                 ;
0000                 ;  FOLLOWING CODE ALLOWS INTERRUPTION FROM "NEXT" ONWARDS
0000                 ;
0000  04  03  22            JMP       ALLOW
0002                 ;
0002                 ;  GIVE RETR SO THAT INTERRUPTION CAN OCCUR
0002  93      21     DUMMY: RETR                 ;RETURN TO ADDRESS "NEXT"
0003                 ;
0003                 ; DUMMY CALL INSTRUCTION PUTS "NEXT" ADDRESS ON STACK
0003  14  02  22     ALLOW: CALL     DUMMY
0005                 ;
0005                 ; INTERRUPTS ARE NOW ALLOWED
0005  00      11     NEXT:   NOP
0006                 ;          ————————
0006                 ;          ————————
0006                 ;          ————————
0006                 ;****************************************
                             END
```

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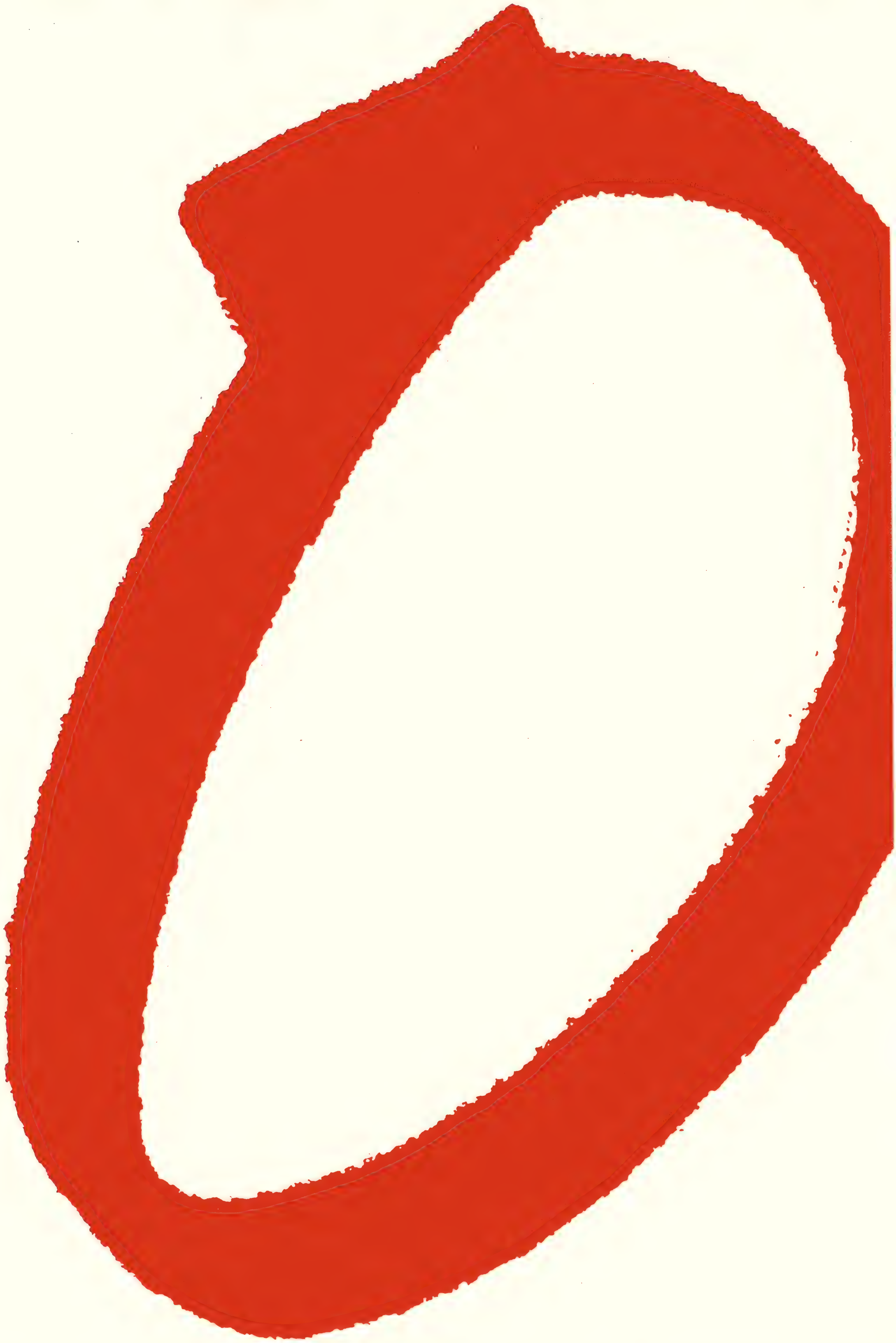

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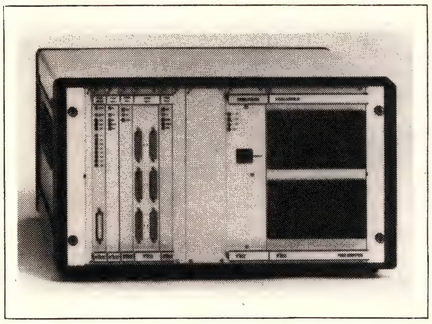

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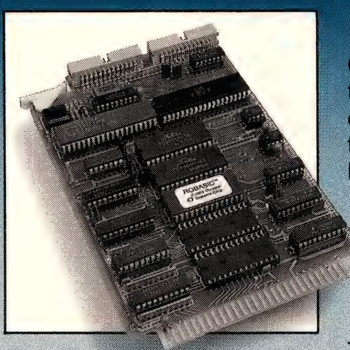

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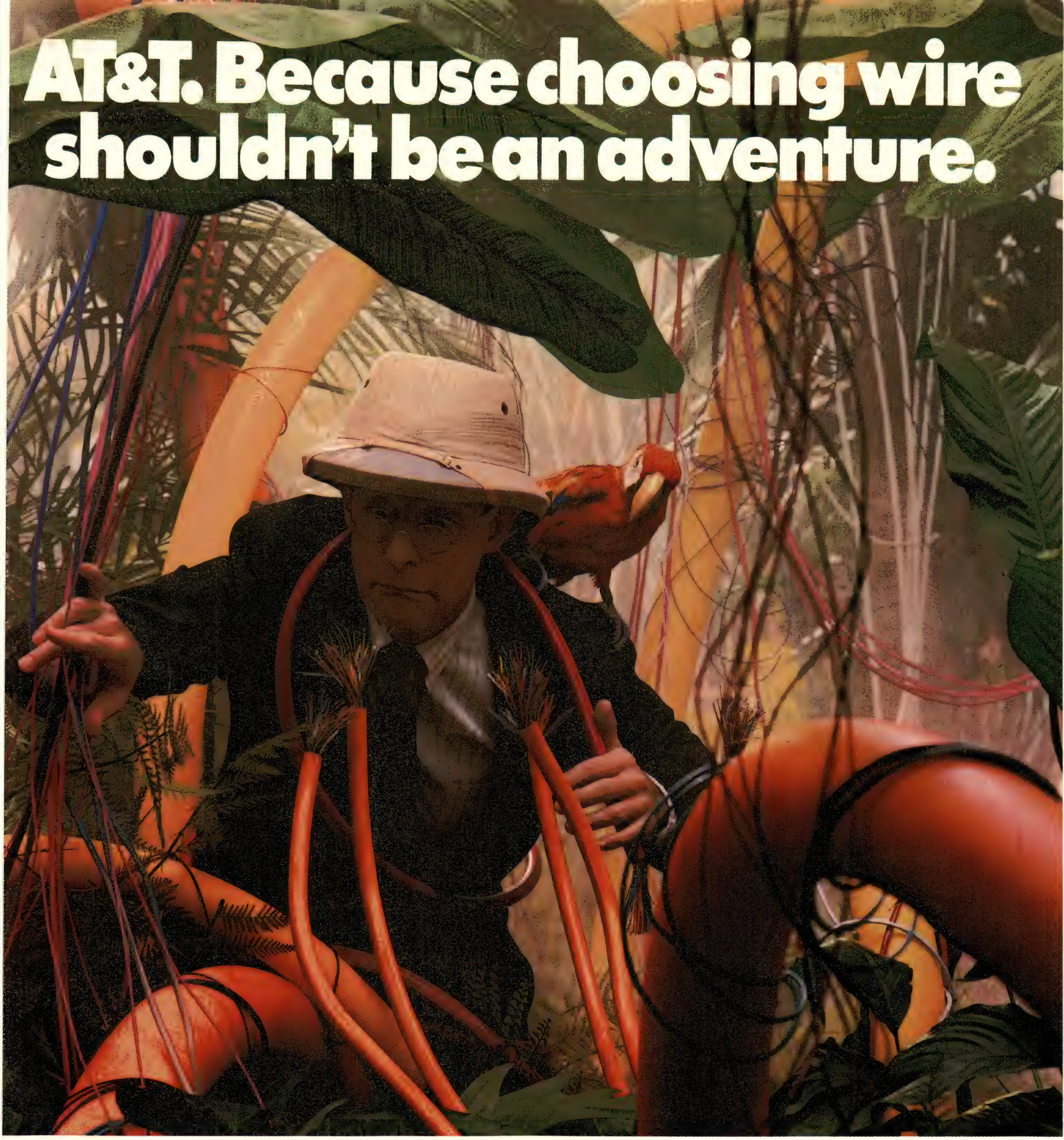

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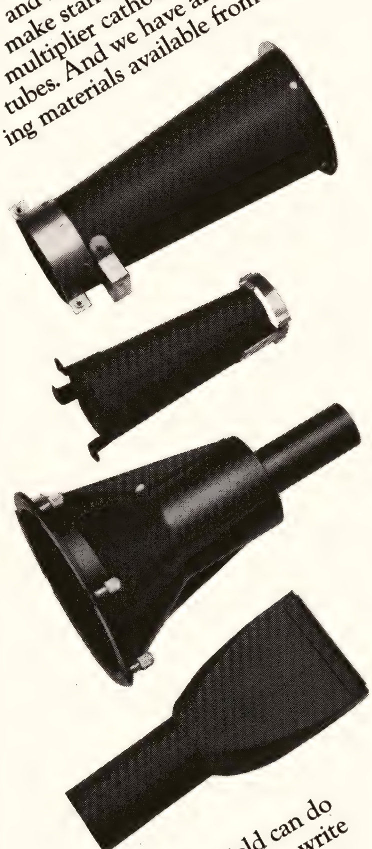

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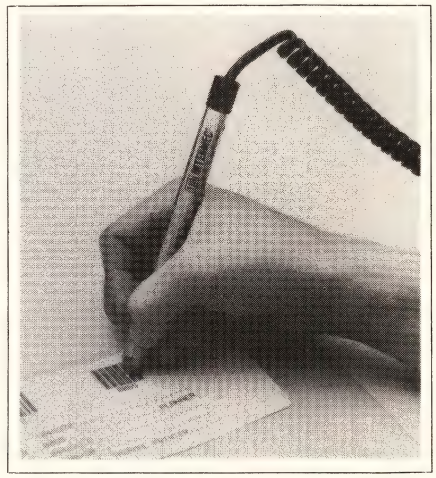

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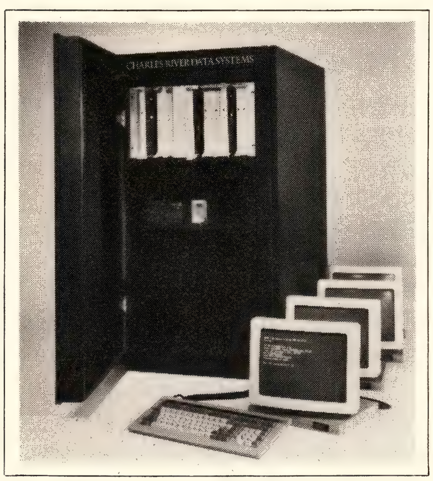

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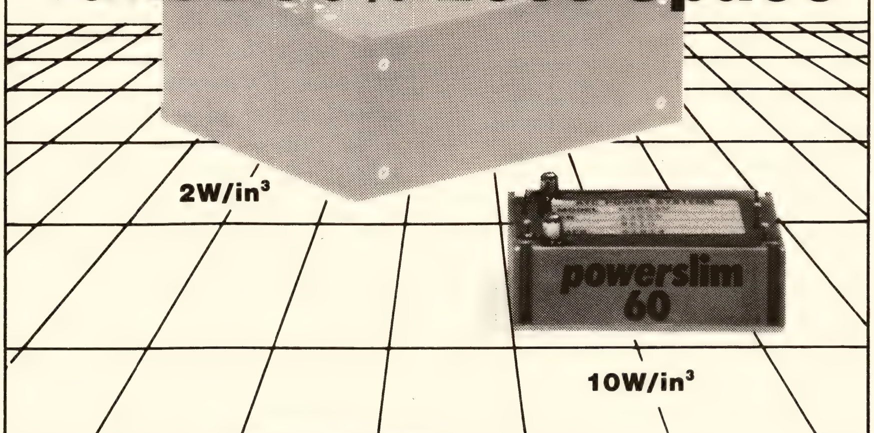

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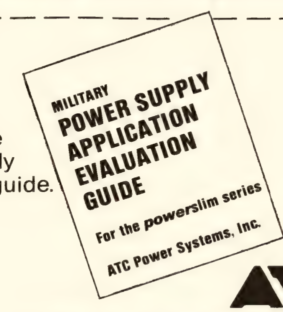

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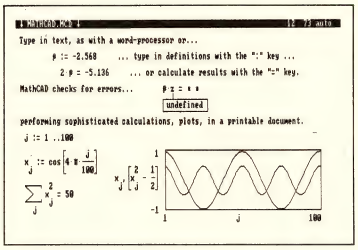

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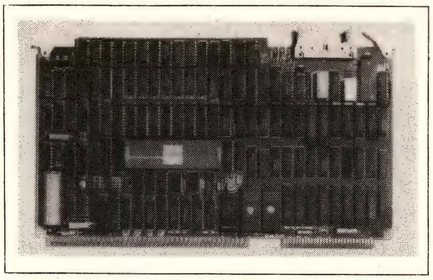
CIRCLE NO 118



CPU CARD

The PMM68K-2 single-board computer for Multibus I systems is based on a 68000 or 68010 μP and features an 8k-byte dual cache memory to minimize wait states. The cache memory is divided into two memory sections, each with a 2k-word capacity, which are updated according to a least-recently-used algorithm to maximize cache hit rates. Cache operation is transparent to the operating system and to Multibus I traffic. An onboard MMU supports both logical address segmentation and physical address paging. You can map as many as 16 processes simultaneously, each with a separate 16M bytes of logical address space. Space is provided on the board for as much as 64k bytes of local EPROM. Eight Multibus interrupt lines are provided. You can opt to operate the board in an autovectored mode. A serial I/O port with programmable baud rate is provided for terminal communication, and you can install an optional battery-backed real-time clock if required. £1984.

Plessey Microsystems Ltd, Water Lane, Towcester, Northants NN12 7JN, UK. Phone (0327) 50312. TLX 31628.

Circle No 390

Plessey Microsystems, 1 Blue Hill Plaza, Pearl River, NY 10965. Phone (914) 735-4661.

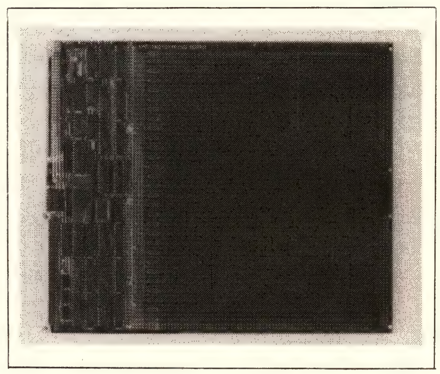
Circle No 391

PRINTHEAD DRIVER

You can use the MTC6033 to drive thermal printheads, ink-jet printers, multiplexed LED displays, or incandescent lamps at peak currents as high as 150 mA. The device includes a 32-bit shift register with a 5-MHz (min) data rate for serial input of data and 32 latch/driver circuits. A serial output allows you to cascade devices at data rates to 3.5 MHz. Although the shift-register, latch, and control circuitries are fabricated in CMOS, the drivers are bipolar open-collector outputs capable of withstanding 40V. Two versions of the device are available with continuous-current-output capabilities of 50 and 100 mA. It comes in passivated, open-back chip form for use in hybrid circuits. Evaluation samples are available in 48-pin ceramic DIPs. BFr 170 (1000); BFr 135 (10,000).

Mietec nv, Westerring 15, 9700 Oudenaarde, Belgium. Phone (055) 332211. TLX 85739.

Circle No 392



PROTOTYPING CARDS

Supplied with a complete VME Bus interface already laid out on the boards, the PG-2750 and -2751 prototyping cards allow you to design VME Bus boards without a detailed knowledge of VME Bus interface requirements. Based on the 68172 VME Bus controller IC, the interface can be configured to operate as a bus master, as a slave, or as a dual-port processor or DMA-oriented master/slave. You can direct the interface, via jumpers, to release bus mastership on a release-when-done (RWD) or release-on-request (ROR) basis. The boards also include software-controlled interrupt generation on any of seven jumper-selectable levels, and an in-

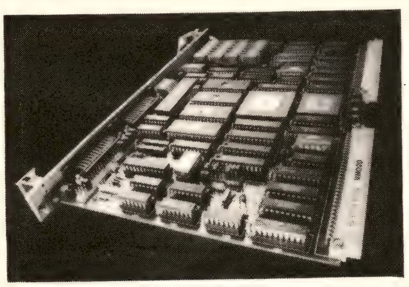
terrupt handler for as many as seven levels of off- or onboard interrupt request. System-controller functions include a single-level bus arbiter. The prototyping area's hole grid pattern is suitable for wrap-and-wire socketing. The board has an internal power supply and ground planes. The PG2750 is a standard double Eurocard, and the PG2751 is an extended (280 mm deep) double Eurocard. $395.

Philips, Industrial & Electro-acoustic Systems Div, Box 523, 5600 AM Eindhoven, The Netherlands. Phone (040) 757005. TLX 51573.

Circle No 393

Signetics Corp, 811 E Arques Ave, Sunnyvale, CA 94086. Phone (408) 991-2000.

Circle No 394



CPU CARD

Featuring a G64 Bus interface on its P2 connector, the VM020 VME Bus CPU card allows you to use low-cost G64 Bus I/O cards in VME Bus systems. The board is equipped with a 12- or 16-MHz 68020 µP, a 68881 math coprocessor, and 1M byte of local memory. Additional facilities include a real-time clock/calendar, status indicators, and two RS-232C/RS-422 serial ports. The VME Bus interface provides for a 16M-byte address space and 16-bit data transfers. The G64 Bus interface provides 1M byte of memory address space and separate I/O space, and it operates with user-selectable 1- or 2-MHz data transfers. It can also accommodate slower G64 Bus slaves. The CPU card supports the OS9/68000 operating system for both disk- and ROM-based systems. Approximately £3000.

Syntel Microsystems, Queens Mill Rd, Huddersfield HD1 3PG, UK. Phone (0484) 535101. TLX 51194.

Circle No 395

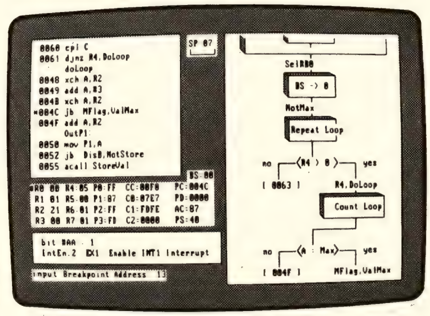
REAL-TIME EXECUTIVE

Rex-186 is a language-independent real-time multitasking executive for Intel iAPX processors. Memory permitting, there is no limit to the number of tasks you can create within a Rex-186 system; you can spawn tasks dynamically, and support full multithreading capabilities. Task communication and synchronization is achieved by ADA-style rendezvous, by which one task signals its desire to enter another task at a specified entry point, and the other task indicates acceptance at that entry point. During rendezvous processing, the tasks are held synchronized to ensure secure data transfers. You can define as many as 16 prioritized entry points within any one task. Any task can ask Rex-186 to make it the owner of particular system interrupts. This feature allows interrupt-driven device drivers to be standard tasks or packages, and it provides a simple intertask or interpackage interface. Hardware-interrupt devices supported include nested 8259s and 8274s used in vectored mode. Rex-186 currently supports 8086, 8088, 80186, 80188, and 80286 (in nonprotected mode) µPs, occupying as much as 8k bytes of memory and requiring approximately 1k byte of static data space. The executive has full-source code, debug software, a terminal driver routine, and a Pascal program that allows you to develop Rex-186 applications on a DEC VAX running under VMS. £7890 for a single-site unlimited copy license.

Rex Systems, 18 Brooklyn Rd, London SE25 4NH, UK. Phone 01 656 8804.

Circle No 396

IBM-PC based microcomputer development tools!



(8051 debug/simulator shown)

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8051	✓	✓	✓
8049	✓	✓	✓
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8088	✓		✓
8085		✓	✓
320		✓	✓
Z8		✓	✓
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P.O. Box 3000
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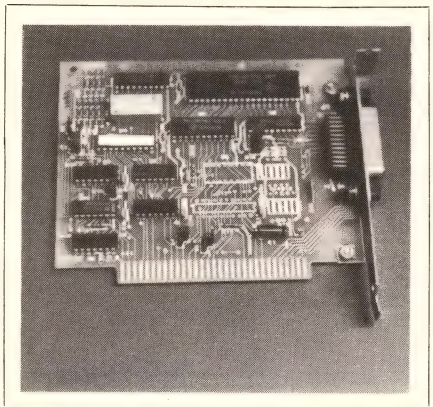
(415) 726-3000 • Telex 171135 Attn: Cyber

CIRCLE NO 119

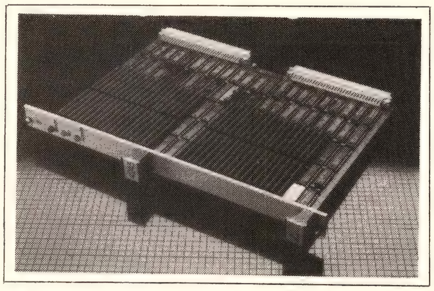


BUS INTERFACE

The PC1325 GPIB interface board allows your IBM PC to control as many as 14 instruments over the IEEE-488 (GPIB) bus. It provides level-2 and level-4 interrupts over the GPIB. Running under MS-DOS, it uses Vistar's instrument operating system (Vios) to facilitate Basic programming. You can configure instruments into hardware test systems under software control in a high-level Basic or instrument-control language. You can use this board with the IBM PC, PC/XT, PC/AT, and compatibles, as well as with the PC1810 IBM expansion chassis. PC1325, $360; Vios software, $90.

Vistar Corp, 13740 McCormick Dr, Tampa, FL 33624. Phone (800) 237-8812; in FL, (813) 855-6611. TLX 522434.

Circle No 378



MEMORY BOARD

Incorporating as many as 4M bytes of dynamic RAM on a dual-high VME Bus pc board, the VME-4246 offers high-speed memory accessing via prefetch caching. Its 32-bit wide data path supports byte, word, and long-word transfers, and is compatible with any VME Bus CPU. The 64-bit prefetch cache provides read data to the VME Bus within 85 nsec on sequential reads. When a read occurs, two full long words are read and latched into the cache immediately, providing a full 64-bit cache block. Noncache read data access time is 255 nsec max with a write access time of 210 nsec. The board features a control/status register (CSR) pair addressed in the VME Bus short I/O space. Byte parity is automatically generated and checked on each memory transaction, and an error is reported by driving the VME Bus BERR line. $2500.

Logical Design Group Inc, 541 Pylon Dr, Raleigh, NC 27606. Phone (919) 834-8827.

Circle No 379

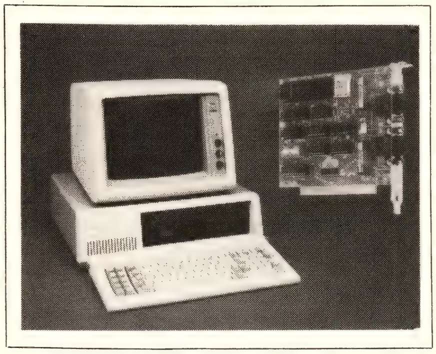
CIRCLE NO 120

VIDEO DIGITIZER

The Image Ace II video capture system can digitize video images from cameras, TV tuners, and video recorders and display them directly on IBM PC screens. It produces images with 320×200-pixel resolution; the capture and display of a full video frame takes 1⅓ sec. The board supports both continuous single-frame and remote-acquisition modes. You can save the compressed 16k-byte image on a floppy disk, transmit it via modem, or print it on a standard dot-matrix printer. You can combine video images with text and graphics for presentations and reports. The software package includes acquisition and display options in easy-to-use windowed menus. High-speed assembly-language routines are combined with Basic. All source code is included. $295.

Lodge Electronics, Box 338, Streamwood, IL 60103. Phone (312) 837-6553.

Circle No 380



NET/COMM BOARD

Using the COM-485 board, you can construct a network over the RS-485 bus for IBM PC/ATs, PC/XTs, and compatibles. Within the system, multiple transmitters and receivers can operate over a 2-wire bus. As many as 32 different driver/receiver stations can communicate at 56k baud, with the stations located as far apart as 4000 ft. You can set up the board as a COM1: or COM2: port, or as a device at any other base-address/interrupt-level combination. A single write operation to the base address +7 ($3FF_{HEX}$ at COM1: or $2FF_{HEX}$ at COM2:) controls the enabling/disabling of the transmitter and receiver section of the board. $180.

MetraByte Corp, 254 Tosca Dr, Stoughton, MA 02072. Phone (617) 344-1990. TLX 503989.

Circle No 381

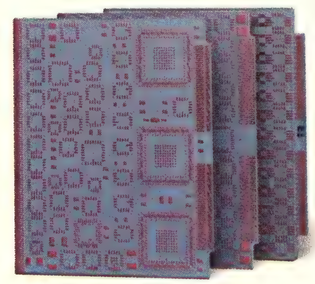
16M-BYTE MEMORY

Incorporating 1M-bit RAMs, the VX86-16MB is a 16M-byte memory expansion board for the VAX 8600 and 8650 computer systems. It allows you to configure systems with as much as 128M bytes of physical memory. Featuring an on-line/off-line switch for simple isolation and troubleshooting, it also has a reconfiguration switch that is used to configure the board as either a 4M-byte or a 16M-byte memory board. $58,000.

EMC Corp, 12 Mercer Rd, Natick, MA 01760. Phone (800) 222-3622; in MA, (617) 655-6600.

Circle No 382

"Having a reliable source of ceramic PWBs has been the problem with using leadless chip carriers. Until now."



Boeing Electronics Company

Reliability By Design

CIRCLE NO 121

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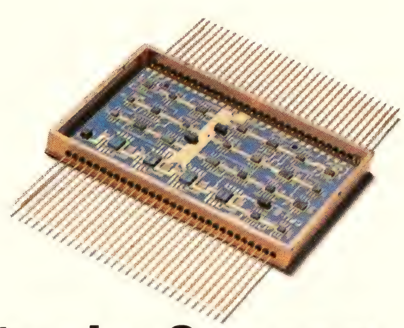


Boeing Electronics Company

Reliability By Design

CIRCLE NO 122

RELATIONAL DATABASE

Version 1.1 of Paradox, a relational database, includes automatic multifile data-entry capabilities, an application generator, new commands, an abridged run-time version for application developers, and the removal of copy protection. With the multifile update facility, you can add or revise data in two or more files simultaneously from a single form. The application generator, by guiding you through the process of selecting the correct options for your application, lets you create database programs without your having to learn how to program. Specific commands allow you to store procedures in binary, rather than ASCII form, for faster program loading and operation. You can also use DOS commands from within Paradox. Other enhancements include improved memory use to increase speed and performance, an improved procedure for importing ASCII files, automatic updating of reports and forms, and facilities for the importing and exporting of data between Paradox, release 2 of Lotus 1-2-3, and release 1.1 of Symphony. Paradox Runtime, a shortened version of Paradox, provides a way to distribute 250 copies of custom Paradox programs. \$695; Paradox Runtime, \$9.95; update kit for nonregistered Paradox owners, \$19.95.

Ansa Software, 1301 Shoreway Rd, Belmont, CA 94002. Phone (415) 595-4469.

Circle No 366

PROTOCOL SOFTWARE

You can now obtain two additional software product layers of the GM-MAP/International Standards Organization (ISO) communication network protocol. The ISO session protocol, layer five, is a C-language implementation of the basic combined subset of the ISO/DIS8326 session specification. With this protocol, you can establish connections, exchange data, and release the connection in an orderly manner. The session protocol interfaces directly to the company's TP4 transport protocol. Also available is the layer two, high-level data link control (HDLC) protocol. The C-language implementation of the data-link protocol supports the balanced class of HDLC, including extended sequence numbering compatible with the 1984 version of X.25 link-access procedures balance (LAPB). One-time source license fee, session protocol, \$6000; HDLC protocol, \$5000.

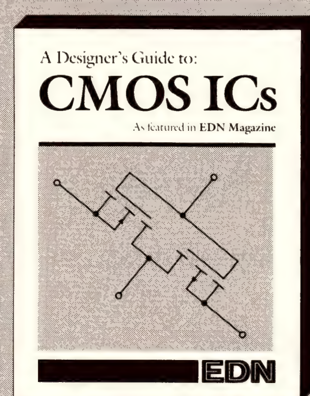
Syros Inc, Box 24477, Tempe, AZ 85282. Phone (602) 897-2399.

Circle No 367

COBOL GENERATOR

The VAX Cobol generator allows you to use a mouse or cursor keys to create diagrams like flow charts

SEE WHAT A *DIFFERENCE* CMOS MAKES!



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that are transformed into VAX Cobol source language programs. The combination of a graphical interface, modular programming methodology, and automatic code generation can speed application development by as much as a factor of ten. The generator produces source-language programs that can run on systems ranging from the MicroVAX II deskside system to the VAX 8800 computer. The generator's application programs can access information stored in a VAX computer system's common data directory and relational base, and it will support record-management system files. From $18,000.

Digital Equipment Corp, 146 Main St, Maynard, MA 01754. Phone (617) 264-1669.

Circle No 368

COMPILER/ASSEMBLER

PL/M 51, a compiler for the high-level language, and ASM 51, an assembler, are software development languages for the 8051 family of microcontrollers. They both run on the IBM PC, PC/XT, PC/AT, and compatibles under DOS 3.0 or later versions, as well as on Intel Series II, III, and IV development systems. The PL/M 51 compiler allows Boolean processing and access to the microcontroller's functions. It includes a syntax checker and cross-reference generation. ASM 51 is a symbolic macroassembler that produces relocatable object modules from 8051 macroassembly language instructions. You can link these modules together as well as link them to object modules generated by other languages. The assembler also provides symbolic access to hardware registers, I/O ports, control bits, and RAM addresses. PL/M 51 and ASM 51, $750 each.

Intel Corp, Literature Dept W288, 3065 Bowers Ave, Santa Clara, CA 95051. Phone (408) 987-8080.

Circle No 369

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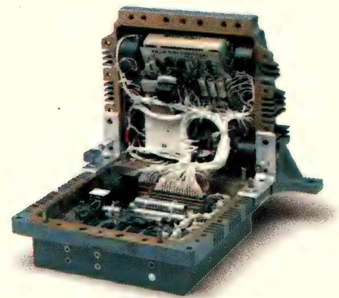

Boeing Electronics Company

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☐ Other ____________

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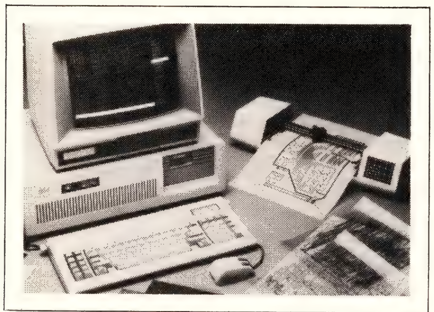


PC-BASED CAE/CAD

The EE Designer consists of three integrated programs that respectively capture schematics, simulate logic, and lay out pc boards. To help you plan a placement and routing strategy, the schematic-capture program places components so that the layout minimizes routing paths; the program then displays rats-nest connections. A back-annotation feature maintains equivalency between the schematic and the layout. The circuit-simulation library provides logic models for 150 standard TTL and CMOS devices. The logic simulator lets you select as many as 12 logical states during a simulation; the program can force signals to predefined states, or it can randomly initialize the state of storage elements like flip-flops. The layout program produces artwork masters for pen plotters, photoplotter outputs, and N/C drill tapes. The complete package runs on all IBM PCs and compatible personal computers that contain 512k bytes of memory. You can control the package's graphics with either a standard IBM color board or a 640×400-pixel Tecmar graphics board. $975. Thirty-day money-back guarantee.

Visionics Corp, 1284 Geneva Dr, Sunnyvale, CA 94089. Phone (408) 745-1551.

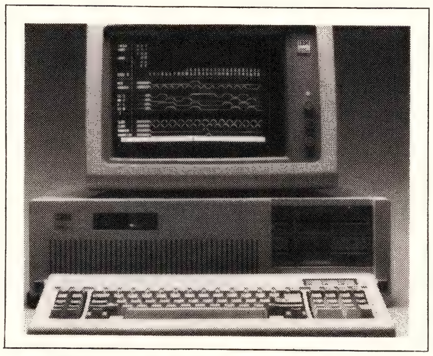
Circle No 350

PC-BOARD LAYOUT

PCBoard Designer, an interactive CAD tool, runs on Atari 520STs or 1040STs that include a monochrome monitor. You can opt for 45° or 90° angle traces; different widths; routing from pin to pin, pin to bus, or bus to bus; and one- or two-sided boards. You select and position components with a mouse. For final artwork, the package transmits data to Epson dot-matrix printers. The package runs under the Gem operating system. $395.

Abacus Software, Box 7211, Grand Rapids, MI 49510. Phone (616) 241-5510. TLX 709101.

Circle No 351



LOGIC SIMULATOR

An identical version of the Cadat logic and fault simulator runs on the IBM PC, PC/XT, PC/AT, MicroVAX, and VAX computers. These systems all use the same command set. Because the simulator can operate as a shared resource on different computers, you can run simulations on whichever computer possesses the right amount of power for your job. The simulator package features switch, gate, and behavioral modeling. Furthermore, it includes concurrent fault simulation and timing analysis with 21-state switch-level simulation. The simulator can compensate for circuit-loading effects and resolve reconvergent fan-out problems and MOS bus contentions. You can display the simulator's output graphically or digitally. The vendor also offers a hardware modeler, which you can interface to multiple workstations through a LAN. The simulator's library includes over 2000 SSI/MSI models. PC/AT version, $4250.

Case Technology Inc, 633 Menlo Ave, Menlo Park, CA 94025. Phone (415) 322-4057.

Circle No 352

HYBRID TESTER

This off-line system for inspecting hybrid circuits, the V20 Vision Workstation, evaluates pattern integrity and location and the accuracy of vertical and horizontal dimensions. You can assign variable tolerances to all patterns and dimensions. The tester resolves features as small as 0.5 mil. Optional programs for solder-dot registration and for laser scribe-line detection are available. The system includes hard- and floppy-disk drives, and it's compatible with the IBM PC. The $75,000 model features an x-y positioning table that holds substrates as large as 4×6 in.

Photonic Automation Inc, 3363 W MacArthur, Santa Ana, CA 92704. Phone (714) 546-6651.

Circle No 353

PC-BOARD CAD

The Trax-PCB pc-board CAD workstation consists of a stand-alone Orca 1000 color-graphics computer system, a hardware-driven autorouter, and layout software. Using this system, you can enter schematic information into a computer database and automatically route your layout. The Orca 1000 graphics system features a 1000-line, 19-in. color monitor; it also comes with 750k bytes of memory, a 1M-byte floppy-disk drive, a 10M- to 50M-byte hard disk, a separate monochrome text monitor, and a keyboard. From $29,900.

Orcatech Inc, 28 Steacie Drive, Kanata, Ontario, Canada, K2K 2A9. Phone (613) 592-7650.

Circle No 354

PC-BOARD LAYOUT

Autoboard provides interactive and automatic placement and routing for pc boards. The package can handle surface-mount, high-density, and analog designs. Instead of following the rip-and-reroute approach of many pc-board routers, this automatic router repositions traces, a method that minimizes the length of board routes. To develop a pc-board routing pattern, the automatic router uses six routing algorithms successively: straight lines, orthogonal bends, single vias, via pairs, pin-to-pin connections, and signal-to-signal connections. The vendor reports that the placement and routing package has automatically completed the layout of a 518-equivalent-IC board, at a density of 0.4 in^2/IC. The package generates output to photoplotters, numerically controlled drill and insertion machines, and automatic test equipment; it also produces documentation and bills of materials. The software runs on this company's 68020-based 32-bit workstation. Software, $20,000; software plus typical hardware, $47,000.

Computervision Corp, 100 Crosby Dr, Bedford, MA 01730. Phone (617) 275-1800.

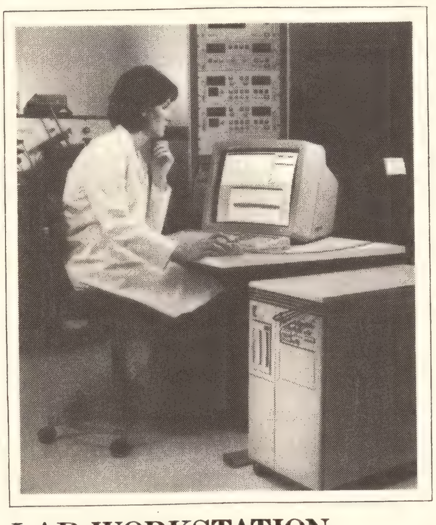
Circle No 399

CIRCUIT SIMULATOR

The Allspice analog-circuit simulation program, which runs on IBM PCs, can now generate graphics output, manage a library of standard components, and link the component models to the user's circuit design. In addition, it now includes a GaAs metal-epitaxial-semiconductor-FET or junction-FET model. The graphics output postprocessor sends data to graphics terminals, dot-matrix printers, or pen plotters. The library program can search for component models or subcircuits; allows you to use node names instead of node numbers; and can evaluate arithmetic expressions, which enables you to scale component values. The library includes models of standard bipolar-junction transistors, MOSFETs, junction FETs, diodes, and op amps. A separate package, Ginger, is a general-purpose plot utility that plots user-defined algebraic expressions of Allspice simulation data. It can also plot instantaneous-power and gain curves. Allspice, $395; Ginger, $225; both packages, $575.

Acotech, 713 Santa Cruz Ave, Suite 2, Menlo Park, CA 94025. Phone (415) 325-7999.

Circle No 400



LAB WORKSTATION

The VAXlab Realtime Workstation is a 32-bit system for laboratory data acquisition and experiment control. You can use optional A/D and D/A converters, clocks, and digital interfaces to control a variety of instruments and sensors. A series of software tools helps you develop your own programs. The workstation uses this company's extended standard Q Bus architecture and a MicroVAX II processor. A single-user configuration includes 2M bytes of memory, a 71M-byte hard-disk drive, a 95M-byte cartridge tape drive, DECnet and Ethernet interfaces, a graphics subsystem, and a real-time clock. The multiuser version incorporates an 8-line communications link instead of a graphics subsystem. From $29,055; typical systems cost less than $50,000.

Digital Equipment Corp, Maynard, MA 01754. Phone local office.

Circle No 401

FILE TRANSFERS

The Analoglink software package lets you use an RS-232C serial interface to transfer this company's files between dissimilar machines. The file-transfer package handles data from either the Analog Workbench or the PC Workbench. You can transfer net lists, circuit descriptions, waveforms, instrument-setup files, and device libraries among Sun, Apollo, and Hewlett-Packard workstations; IBM PCs; and VAX minicomputers. $500.

Analog Design Tools Inc, 66 Willow Pl, Menlo Park, CA 94025. Phone (415) 328-0780.

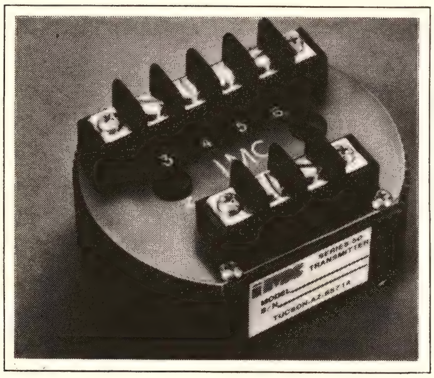
Circle No 402

FAILURE PREDICTOR

Operating on an IBM PC, PC/XT, or PC/AT, PC-Predictor can project the reliability (MTBF), safety, and maintenance needs of a design at any stage of system development. To predict component failures, the package relies on a library of the Electronic Industry Standards for Prediction of Failure Rates and of MIL-HDBK-217 standards. The library contains 40,000 components. $5500.

Control Data Corp, Box 0, Minneapolis, MN 55440. Phone local office.

Circle No 403

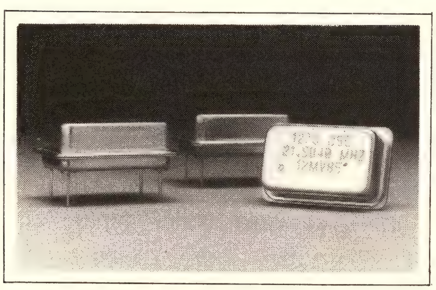


TRANSMITTER

The Transpuck current-loop transmitter mounts inside explosion-proof enclosures. Five functions are selectable by DIP switch: thermocouple with open temperature-coefficient detection; resistance-temperature detection with open element detection; resistance; millivolts dc; and strain gauge with internal/external excitation. Power-input voltage ranges from 12 to 40V dc, and output accuracy is ±0.01% of full scale. Current output spans 3 to 34 mA. Temperature coefficient is 5 ppm/°C, power-supply rejection ratio is 130 dB, and zero and span range is ±50%. Response time is 10 msec. The operating range spans −40 to +80°C. $125. Delivery, stock to six weeks ARO.

International Microelectronics Inc, 4016 E Tennessee St, Tucson, AZ 85714. Phone (800) 847-8478; in AZ, (602) 748-7900. TWX 910-952-1170.

Circle No 360



OSCILLATORS

Available in frequencies from 0.5 to 33 MHz, these voltage-controlled crystal oscillators feature a tuning range of ±100-ppm min with a control voltage of 2.5±1.5V. They come in standard 4-pin metal DIPs and operate from a 5V power supply. When used in conjunction with a phase-sensitive detector, the devices provide a means for the regeneration of carrier or clock signals that have been corrupted by noise. $11 to $17.

AT&T Technology Systems, 1 Oak Way, Room 2WC-106, Berkeley Heights, NJ 07922. Phone (800) 372-2447.

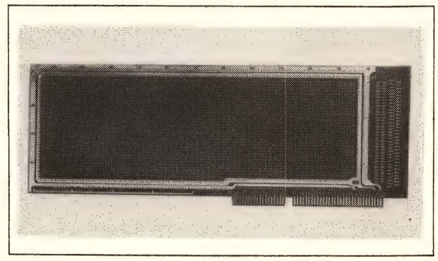
Circle No 361

PRESSURE SENSOR

Made for harsh environments, the SSX100G stainless-steel 100-psig transducer is trimmed to a 100-mV full-scale output (within ±1%). The zero pressure offset is also set to within ±500 μV of zero voltage. The device is temperature compensated to limit typical thermal shifts to ±0.01%/°C from 0 to 70°C. Although it operates optimally within that range, the device will perform from −40 to +85°C. Typical accuracy (combined linearity, hysteresis, and repeatability) is ±0.3% of full-scale output. The transducer is guaranteed for operation with a 12V supply; however, the output is ratiometric to the supply voltage, and any supply from 5 to 30V dc is acceptable. The sensor handles any media compatible with 303 stainless steel. A 4-conductor shielded cable is provided for electrical connection. Pressure connection is made via ⅜-in. female national taper-pipe threads that allow direct-pressure connection or the use of a number of standard male-male fittings for connection. $125 (100).

SenSym Inc, Industrial Products Group, 1255 Reamwood Ave, Sunnyvale, CA 94089. Phone (408) 744-1500. TWX 910-339-9625.

Circle No 362



PROTOTYPING CARD

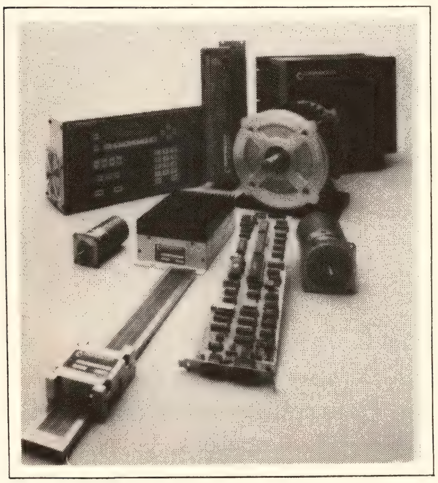
Designed for the IBM PC/AT, the 4617-3 prototyping board has a pad-per-hole layout pattern with 0.042-in. holes on 0.1-in. centers. This board, which has plated-through holes, accepts any width DIP IC or wire-wrapping terminals. Power and ground buses are located on each side around the edges of the card and terminate to connectors. Connector pads on the board and accompanying bracket accept 9-, 15-, 25-, or 37-pin I/O connectors. The board measures 13.25×4.8 in. and fits a full slot on the PC/AT. The board is fabricated of 0.062-in.-thick FR4 green epoxy-glass material, and the pads and buses are 2-oz copper with reflowed solder plating. Card-edge connector contacts are gold over nickel plate. $43.53.

Vector Electronic Co, Box 4336, Sylmar, CA 91342. Phone (818) 365-9661. TWX 910-496-1539.

Circle No 363

INDEXER

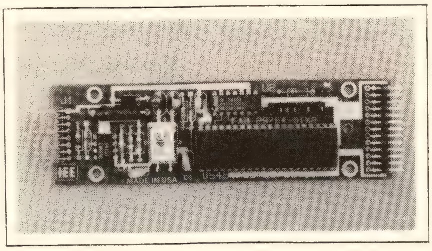
The Model PC21 board-level motion-control indexer is compatible with the TI Professional Computer. It relieves the TI μP of housekeeping chores by means of the indexer's



8085-based interface. The indexer accepts high-level commands from the computer at its own address on the computer's bus. Thus you can use multiple indexer cards in the computer or expansion chassis. You can assemble a sequence of 300 commands and store it on the indexer. An external signal or command from the computer can later enable a sequence of activities that occurs simultaneously with the computer's processing of other tasks. The unit works with end-of-travel limit switches, trigger inputs, and a programmable output. An encoder interface that's compatible with most TTL optical incremental encoders is standard. $795.

Compumotor Corp, 1179 N McDowell Blvd, Petaluma CA 94952. Phone (800) 358-9068; in CA (707) 778-1244 (collect).

Circle No 364



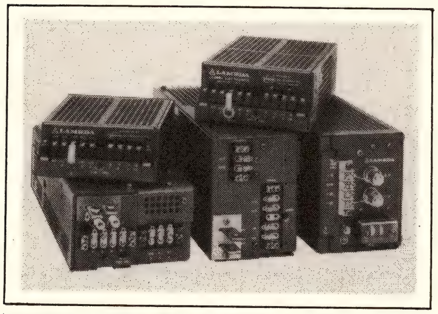
DATA CONVERTER

The LC/SDCM (29749-02) is a serial data converter module for remote operation of the Daystar Nova family of LCD modules. You can use an RS-232C, RS-422A, or 20-mA current loop to write data to the converter. The input circuit is optoisolated for noise rejection. Data rate can be 300, 1200, 2400, or 9600 baud. The data converter features a self-test, a system-diagnostic mode, parity and rate-error detection, hardware reset, and an LED lamp to indicate when data is being received. The module has a CMOS μP that draws 40 mA at 5V dc. It is also compatible with any LCD module with a Hitachi HD44780 compatible controller. $28 (100). Delivery, four to six weeks ARO.

IEE Inc, Industrial Products Div, 7740 Lemona Ave, Van Nuys, CA 91405. Phone (818) 787-0311.

Circle No 365

CIRCLE NO 125



400W SWITCHER

The LRS-56 400W switcher, an addition to the manufacturer's LR Series switching power supplies, provides 2.5W/in³. The device features 2-board construction. An EMI filter, standard in all units, meets MIL-STD-461A and FCC Docket 20780 Class A. The LRS-56's low parts count creates a high MTBF. It's guaranteed for five years. $725.

Lambda Electronics, 515 Broad Hollow Rd, Melville, NY 11747. Phone (516) 694-4200.

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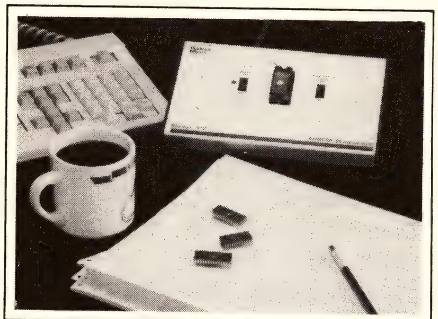
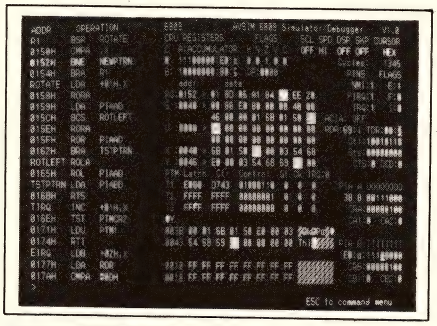


EPROM PROGRAMMER

The Blaster 512 EPROM programmer operates with an IBM PC or compatible computer. The programmer's menu-driven control software runs under MS-DOS. The unit programs all single-voltage EPROMs, from 16k to 512k bits in both the 25XX and 27XX families without requiring personality modules. Programmable devices include the new 27512 and 27513 EPROMs. The software, which includes intelligent-programming algorithms, employs a virtual data buffer that handles any size EPROM. To insure proper operation, the programmer runs a self-test diagnostic each time you start it. Any necessary recalibrations require only a digital voltmeter. Minor changes to the EPROM driver software let the programmer operate with computers that run MS-DOS but are not IBM compatible. You can program EPROMs from either Intel hex, Motorola S-record, Tektronix hex, or binary files. You can operate on an EPROM's data by copying it into a file, comparing it with a file, or displaying it. You can also change individual EPROM locations with keyboard entries. $840.

Hudson Micro, Box 93, Hudson, NH 03051. Phone (603) 889-6486.

Circle No 384



6809 SIMULATOR

The AVSIM09 is a software simulator for the 6809 µP that runs on an IBM PC. The program interpretively executes 6809 object code under control of a full-screen symbolic debugger that eliminates the need for special hardware. In operation, the PC displays flags, program, and data memory. You can use editing keys to manipulate these objects on-screen and use function keys such as Single-step, Breakpoint, and Run to control program flow for debugging. The Undo key uses the device's trace memory to back up one-at-a-time through recently executed instructions. You can access a breakpoint facility through screen menus and a command mode. The device simulates peripheral devices including the 6821 PIA, 6840 PTM, and 6850 ACIA. $299.

Avocet Systems Inc, Box 490, Rockport, ME 04856. Phone (800) 448-8500; in ME (207) 236-9055.

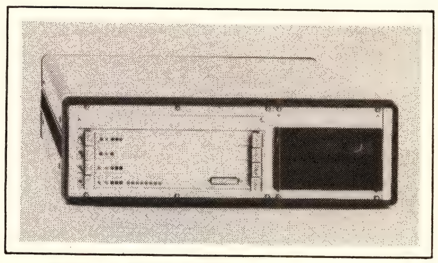
Circle No 385

IEEE-488 INTERFACE

The Parallel 488 links devices having Centronics interfaces with IEEE-488 computers, peripherals, and instruments. You can configure the device to convert from Centronics to IEEE-488 or vice versa. In the latter mode, the device transfers data received from an IEEE controller to a Centronics printer or plotter. Its built-in 8000-character data buffer allows the IEEE controller to continue IEEE-488 bus activity while the linking device spools data to the Centronics interface. $495.

IOtech Inc, 23400 Aurora Rd, Cleveland, OH 44146. Phone (216) 439-4091.

Circle No 386

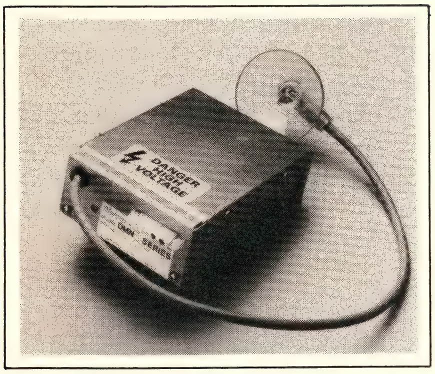


UNIX SYSTEM

The Microforce 1A runs AT&T's Unix V on a 68010 µP and has a 128k-byte, local, no-wait-state memory; 2M bytes of global VME-board main memory; one VME expansion slot; and 50M bytes (unformatted) of Winchester storage. The system includes four serial I/O channels, a printer, and a communications port. In a 16×16×6-in. desktop package, $8995.

Force Computers Inc, 727 University Ave, Los Gatos, CA 95030. Phone (408) 354-3410.

Circle No 387

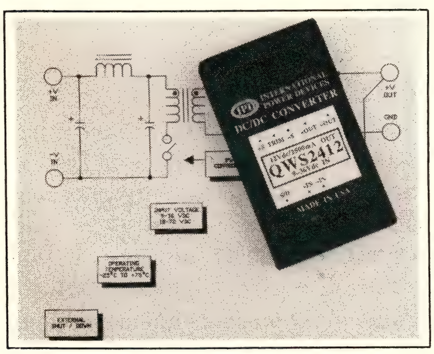


CRT SUPPLIES

The series DMN high-voltage CRT power supplies provides regulated voltages as high as 20 kV at 10W for direct-view monochrome CRTs. The devices feature 0.01% p-p ripple and noise, foldback current limiting, and a voltage drift of ±100 ppm/°C max. The devices require a 24V input voltage and operate at 100 kHz. The supplies provide G2 output voltages as high as 1 kV with a 0.05% p-p ripple, and G1 voltages as low as −200V with a 0.05% p-p ripple. Outputs are arc- and overload-proof. The units also feature filtered input leads and a remote on-off control input. The supplies come in a 3.1×4.1×1.4 in. case that has no open seams. $55 (1000).

Display Components Inc, 334 Littleton Rd, Westford, MA 01886. Phone (617) 692-6000.

Circle No 388



DC/DC CONVERTERS

The QWS Series single-output dc/dc converters are 85% efficient. The devices accept input voltages with over a 4:1 ratio of either 9 to 36V or 18 to 72V. They provide ±1% load regulation (no load to full load) max and ±0.5% line regulation max. I/O isolation is 500V dc min. You can configure the output of several modules in parallel. All models offer a TTL-level remote on/off control pin. Ripple and noise is 50 mV p-p at a 20-MHz bandwidth; transient response is <500 μsec, and temperature coefficient is ±0.02%/°C. The devices operate over −25°C to +71°C with no derating. The devices come in a 6-sided case shield to eliminate noise radiation. Outputs of 5V at 5A, 12V at 2.5A, and 15V at 2A are available. $179.

International Power Devices Inc, 155 N Beacon St, Brighton, MA 02135. Phone (617) 782-3331. TLX 650-273-8631.

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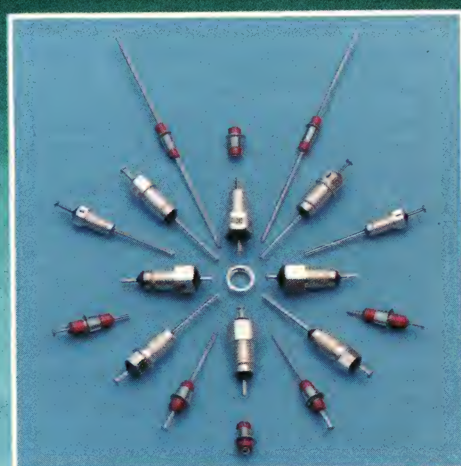

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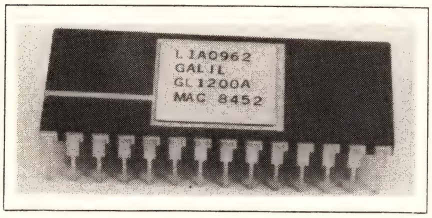

CONTROLLER IC

The GL-1200-10 single-chip dc motor controller accepts pulse-input commands at frequencies as high as 600,000 Hz. The device operates from a 10-MHz clock. You can command the IC to follow any velocity profile at speeds varying from 0 to 600,000 counts/sec. For speed-control applications requiring phase-locked accuracy and a wide speed range, the device interfaces to a remote pulse generator or crystal oscillator. For positioning systems, it interfaces to indexers, allowing you to convert from stepping-motor positioning systems to dc-motor systems without changing input hardware. The chip accepts position feedback from an incremental encoder and decodes the 2-channel pulses into quadrature counts. The device also provides damping signals for system stability. In a 28-pin DIP, $23 (10,000).

Galil Motion Control Inc, 1928-A Old Middlefield Way, Mountain View, CA 94043. Phone (415) 964-6494. TLX 171409.

Circle No 370

TV MEMORIES

The μPD41101 and μPD41102 high-speed image-processing memories are capable of storing digital video signals for one television scan line. Each device uses a 3-transistor memory cell with independent input and output arranged to sample and store television signals for each scan line. The μPD41101 is a 910-word×8-bit device for use in NTSC-standard television systems in the US and Japan. The μPD41102 is a 1135-word×8-bit device intended for use in PAL-standard television systems in Europe. Access times available for the -41101 version range from 27 to 49 nsec; for the -41102, from 21 to 40 nsec. Both devices feature a built-in serial selector for FIFO read/write operations. In a 300-mil plastic DIP, μPD1101C, from $20; μPD41102C, from $25 (100).

NEC Electronics Inc, Box 7241, Mountain View, CA 94039. Phone (415) 960-6000. TWX 910-379-6985.

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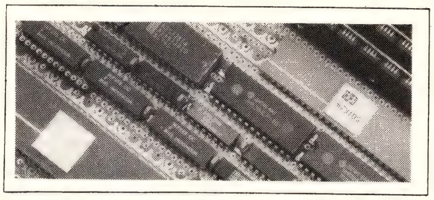


RAM CONTROLLERS

The 673102, which supports 256k-bit dynamic RAMs, and the 673103 and 673104, which support 1M-bit dynamic RAMs, are equipped with multiple and independently controlled column-address-strobe (CAS) outputs for single-byte access in 16- and 32-bit systems. The devices feature autoaccess, externally controlled access, and refresh. The 48-pin 673102 addresses 2M bytes of memory; the 52-pin 673103 addresses 8M bytes of memory; and the 64-pin 673104 addresses 16M bytes of memory. In ceramic DIPs, the 673102, $18; the 673103, $34; the 673104, $40 (OEM qty).

Monolithic Memories, 2175 Mission College Blvd, Santa Clara, CA 95054. Phone (408) 970-9700. TWX 910-338-2376.

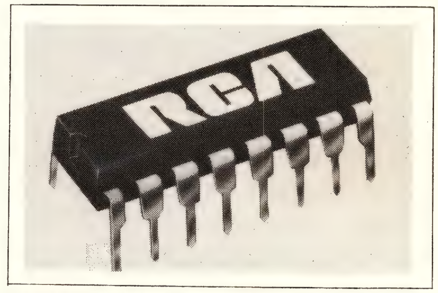
Circle No 372

DRIVER IC

The TDA7250 is a high-voltage, dual driver IC. The device can drive two pairs of external power transistors to configure amplifiers in the 15 to 100W range. The IC operates over a power-supply range of 16 to 70V. It specs distortion of 0.02% from 20 Hz to 20 kHz. The driver incorporates quiescent-current control for the power-transistor stages. In addition, it has built-in output-current overload protection. The device comes in a 20-pin DIP or a surface-mount package. $2.51 (1000).

SGS Semiconductor Corp, 1000 E Bell Rd, Phoenix, AZ 85022. Phone (602) 867-6100. TLX 249976.

Circle No 373



SHIFT REGISTER

The HC/HCT40104 is a 4-bit universal shift register that has bidirectional capabilities and provides 3-state output lines. Two mode-select input lines control the device's operating modes. The DSL and DSR input pins provide serial operation. Typical propagation-delay time from a clock-pulse input to the appearance of data at any ouput is 17 nsec at 25°C with a 5V supply and 15-pF load. Both the HC and HCT types accept clock pulses at a 50-MHz rate when operating from a 5V power supply at 25°C. In a 16-lead plastic DIP, $1.40 (100).

RCA, Solid State Div, Route 202, Somerville, NJ 08876.

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The ZVN14 MOSFETs have turn-on and -off times in the subnanosecond range; input and output capacitances are 6.5 and 3.0 pF, respectively. The devices feature drain-source breakdowns to 90V for drain-current requirements as high as 10 mA. They have a vertical DMOS structure and come in an E-Line TO-92 transistor pack. $0.20 (10,000).

Ferranti Semiconductors, 87 Modular Ave, Commack, NY 11725. Phone (516) 543-0200.

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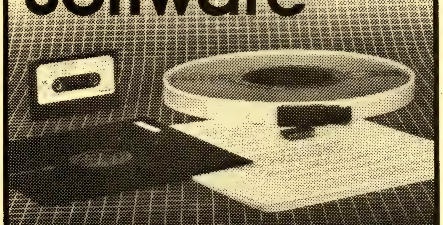

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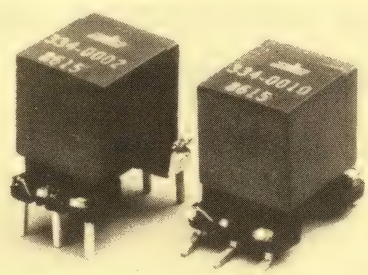

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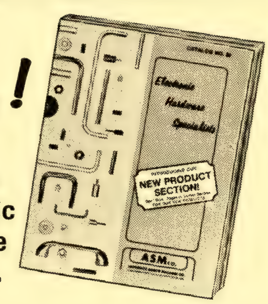

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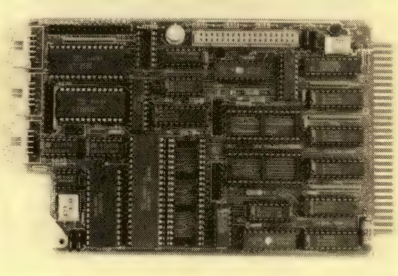

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WinSystems, Inc.
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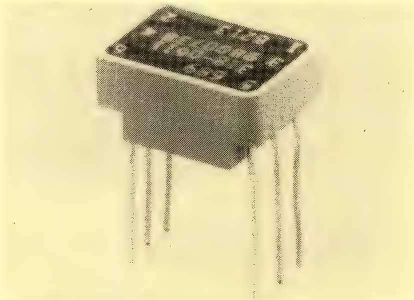

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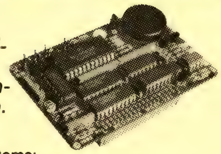

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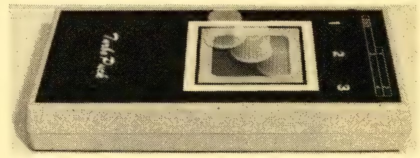

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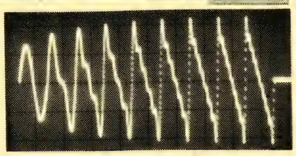

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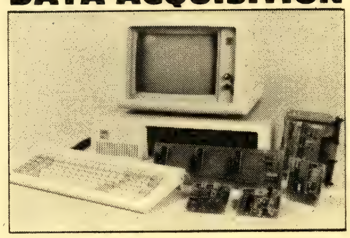

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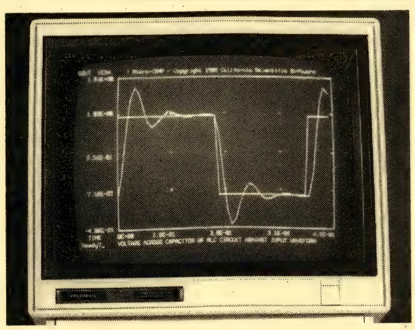

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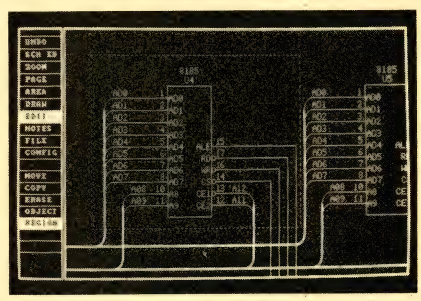

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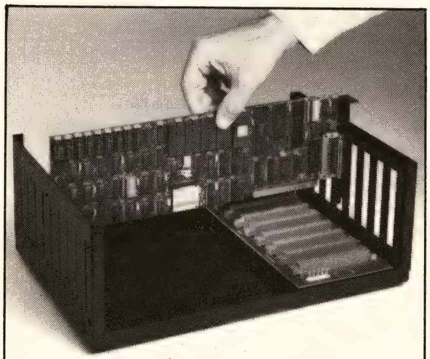

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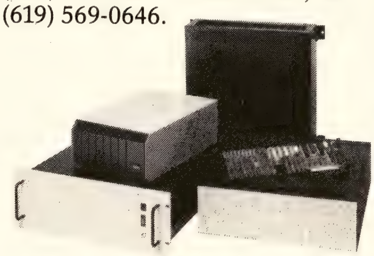

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This product-selection guide lists linear ICs housed in leadless chip carriers that meet JEDEC specifications. The brochure contains information on precision operational amplifiers, instrumentation amplifiers, matched transistor pairs, voltage references, D/A converters, analog switches, analog multiplexers, S/H amplifiers, and voltage comparators. All devices listed meet MIL-STD-883, Class B, Revision C.

Precision Monolithics Inc, Box 58020, Santa Clara, CA 95052.

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Guide to controllers

This pocket guide, which measures 4×9 in., is intended for peripheral-controller users of DEC computer systems. The booklet catalogs the company's products for use with MicroVAX I and II, LSI-11, PDP-11, and VAX machines. These products include storage-module-drive disk controllers, ESDI disk controllers, ¼- and ½-in. tape couplers, floppy-disk controllers, and asynchronous-communications controllers. In addition, the guide lists all disk and tape drives compatible with the company's controllers and couplers and DEC computers.

Dilog, Box 6257, Anaheim, CA 92806.

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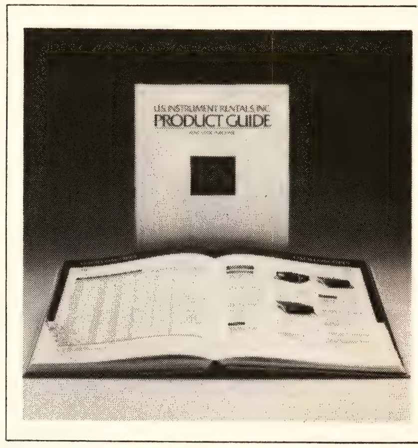

Book references products for rent

This 1986-87 catalog features the 4351 electronic test and measurement products that the manufacturer has available for rent. The 368-pg, hardbound guide provides descriptions, specifications, and comparison charts of test instruments in 14 categories. Among the products detailed are analyzers, µP development systems, counters, desktop controllers, generators, meters, oscilloscopes, recorders, signal modifiers, telecommunications devices, and CAE/CAD equipment.

United States Instrument Rentals Inc, 2988 Campus Dr, San Mateo, CA 94403.

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Data on MIL connector

This 16-pg brochure details the 801/801CX Series 2-part pc-board connector, which adheres to MIL-C-55302/140-155. The catalog provides data on electrical and material specifications, and it covers the hexagonal and quadrangular guiding systems as well as connector styles and contact-cavity identification. Charts and diagrams provide dimensional drawings and graphic representations. Ordering information and an intermatability chart are also included.

McMurdo Connectors, Box 248, Lexington, MA 02173.

Circle No 407

Efforts to draw minorities to engineering make progress but still face obstacles

Deborah Asbrand, *Staff Editor*

Efforts to encourage minority students to consider engineering careers took off in the 1970s and produced a surge in the number of minority students enrolled in undergraduate engineering programs. As a result, minority men and women gained a toehold in the engineering profession, improving their representation from less than 1% to 4.6%. For the past two years, however, minority engineering enrollments have been flat. Supporters of the minority engineering effort worry that the current conservative political climate, coupled with the continuing obstacles of poverty, poor education, and racial prejudice, could impede the effort's progress.

The 1970s were years of great growth for the movement to recruit minority men and women into engineering. The roots of the National Action Council for Minorities in Engineering (NACME), a leading proponent of the effort, were begun in 1973 when 300 engineers, educators, and industry representatives met to launch a concerted effort to groom more minority students for careers in engineering.

Programs to recruit and support minority engineering students were set up at 80 colleges throughout the country. The programs, often funded by industry, had two principal functions. The first was to provide support services for the minority men and women who were studying engineering. The second function was to increase minority enrollments. To achieve this goal, many college programs turned to nearby high schools. College representatives worked with high school officials to sponsor career fairs and introductory programs to develop students' interest in engineering.

The results of these efforts slowly began to appear: By 1982, the number of minority students enrolled in freshman electrical engineering programs had jumped to more than 11,000 from 3200 just 10 years earlier. Formed to support both engineering students and professionals were specialty organizations like the Society of Hispanic Professional Engineers, the Mexican American Engineering Society, the American Indian Science and Engineering Society, and the National Society of Black Engineers.

College support programs, which have shouldered much of the responsibility for guiding more minorities toward engineering careers, work against the complex forces of poverty, poor public education, an atmosphere of lower expectations in many inner city schools, and racial and ethnic biases.

Between 1982 and 1984, however, minority engineering enrollments remained flat, and universities with active minority-recruitment programs have seen little for their efforts. Despite an aggressive recruitment program, minority engineering enrollments at Purdue University in Lafayette, Indiana, have shown little growth for the past three years, hovering around 5% of the total undergraduate engineering enrollment. At the Amherst campus of the University of Massachusetts, minority enrollments in the school's engineering department have seen steady decline for the past three years. Dwight Tavada, assistant director of the university's minority engineering program, says that applications for admission this September are down 5% to 10%.

Tavada attributes the declining enrollments to the country's swing away from progressive values and the de-emphasis on affirmative action. "The current administration has negated some of the headway that's been made in the past 10 years," he says. Tavada notes that the change in attitude has made his job more difficult, as he tries to attract interest, support, and funding from the university and from industry. "We have to explain ourselves more these days, and that keeps us from doing what we're supposed to be doing."

Nationally, several recent reports have stressed that the encouragement of minority students to take on engineering must remain a priority of the engineering community in all sectors. According to a 1985 report by the National Academy of Engineering, although minorities constitute 28% of the population, only 4.6% of engineers belong to minority groups. Of this small group, two-thirds are Asian-American. Black men and women, who account for 12% of the general population, represent less than one-third of all minority engineers. Hispanics and American Indians are represented in trace numbers.

A more critical report from the Congressional Office of Technology Assessment questions whether the effort to recruit more minority stu-


Marc Berlow

Sherita Brown, senior engineer: "Students seem surprised that someone my age could be where I am today. They can't understand that it's not a matter of luck; it's a matter of self motivation and determination."

dents into engineering can surmount the problems it faces. For "blacks and Hispanics, the causes of low participation are so deeply entwined with larger social and cultural factors that the prospects for further improvements without dramatic societal intervention do not seem very bright."

Most of the successes to date can be attributed to the efforts of the private and educational sectors. Much of the support of minority students has grown out of colleges and universities and has been financed by industry. For example, the minority engineering program at the state-supported University of Massachusetts derives 80 to 85% of its funding from corporate sponsors. Industry sponsors also fund NACME's $3.5 million scholarship program. The scholarship program is the country's largest for minority students, providing financial support for 10 to 12% of all minority engineering students.

Although the number of companies that contribute is only a tiny fraction of what it could be, many schools are finding corporations to be ready, albeit untapped, donors. At the Illinois Institute of Technology (IIT) in Chicago, Nathaniel Thomas, director of the school's preuniversity and minority program, has assembled a scholarship fund for his own program in addition to the financial awards the Institute administers. By approaching companies and successfully arousing their interest in the minority students graduating from his school's engineering department, Thomas has amassed a $450,000 scholarship fund for minority students.

Industry representatives mince few words as to why some companies are so generous in their support of minority programs. Robert Mills, manager of professional recruiting and university relations at General Electric's headquarters in Fairfield, CT, has been involved with the minority engineering effort since it first took shape in 1973. Of industry's sponsorship of NACME he says, "The effort was started by corporations as filling a business need. Their thoughts were on employment, not social action." To secure government contracts, for example, companies have had to meet Equal Employment Opportunity (EEO) requirements set by the Department of Labor.

Conspicuous in its absence from the minority engineering effort has been assistance from federal and state governments. The Office of Technology Assessment's report admonished the federal government for its lack of contribution to the effort. Although the 1981 National Science Foundation Authorization Act required President Reagan to deliver by 1982 a proposal for a comprehensive national policy for promoting minorities and women in science and technology, that requirement has been ignored. Yet with a payroll that includes 15% of the country's engineers, the federal government has a business stake in the effort to recruit more engineers and should be an active participant in the minority engineering effort, says Mills.

Little action has been taken at the state level. In Massachusetts, despite being the only minority engineering program in the state's public education system, the Amherst campus's program receives little funding from the state legislature—a fact that Tavada says does not sit well with the program's corporate donors, who are willing to subsidize the program, but are not willing support it completely. Tavada says he is under pressure from industry sponsors to obtain more funding from the Massachusetts legislature.

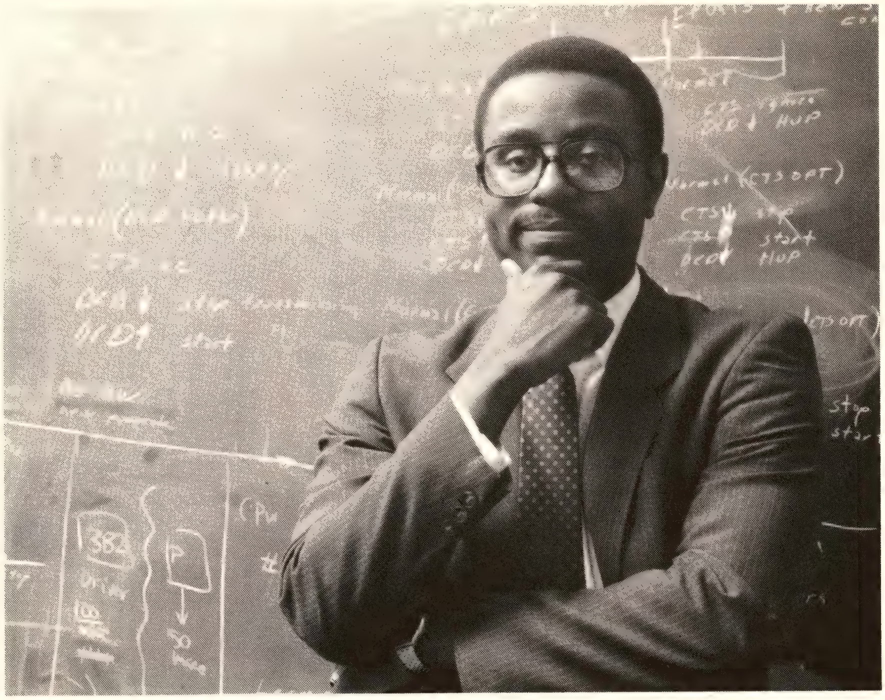
Some states do take a material interest in such programs, however. In Washington, the state legislature

recently set aside $250,000 to assist minority students enrolled in the state's five engineering schools. California's statewide Mathematics, Engineering, Science Achievement (MESA) Program continues to expand and to garner accolades, as it has since its inception in 1970. The MESA program works with more than 4800 students in 180 California high schools to boost their math and science participation. In addition, the program operates 15 college support programs.

Cooperation between the appropriate representatives of industry, government, and education is badly needed to attract more minority students to engineering. College support programs, which have borne the brunt of responsibility for the task, work against a complex, tightly woven web of social forces. Minority students often suffer the effects of poverty, poor public education, an atmosphere of lower expectations that pervades many inner city schools, and racial and ethnic biases.

Complicating the support programs' work are engineering's stiff math and science requirements. Unlike many other professions, adequate preparation for engineering begins long before college. "The problem with engineering is that preparation starts at the junior high level," says Luis Miranda, NACME's field services director. "Eleventh or twelfth grade is just too late. If you don't have the math and science background, the chances of getting admitted are slim to none. When you're 13 or 14 years old, you're not thinking about whether you want to be an engineer, but it's at that point that you're making decisions that will allow you to go into the field."

Recognizing this need for an early start, most minority engineering departments sponsor programs that reach back into the high schools and junior high schools to spark students' interest in math and science and then to encourage those students that develop an interest to consider technical careers. At Purdue University, more than 100 seventh and eighth grade students participate each summer in a week-long program designed to help them in their math and science courses. Purdue runs similar summer programs for high school freshmen, sophomores, and seniors.



Marc Berlow

Danny Creed, supervisor: When the school newspaper began publishing letters that alleged admission standards had been lowered to accommodate minority students, "I was determined not to let those comments become a self-fulfilling prophecy."

Each spring, the Illinois Institute of Technology invites selected high school students to spend three Saturdays designing a technical project. "For the first time, they're using math in context with science, physics, and chemistry, and they're doing something with them," says Nathaniel Thomas. "The subjects become more than just abstract blackboard subjects." The same students come back for a 6-week summer session, during which they design more complex projects and study math, physics, chemistry, and English. They're graded on the projects they build as well as their ability to explain how they used their math and science skills to design and build them.

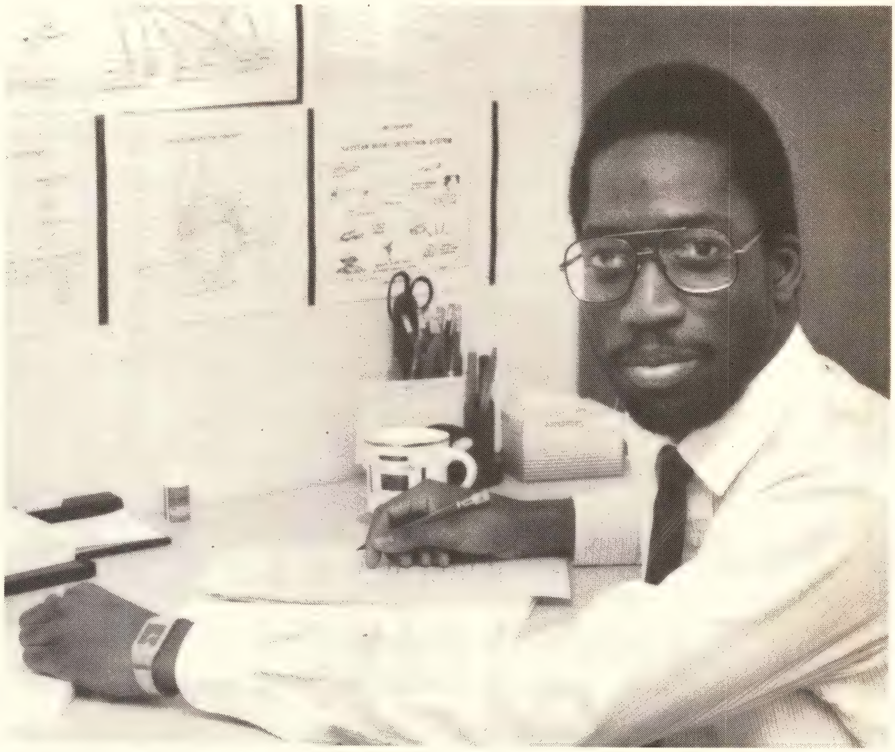
Although colleges and universities sponsor these programs to boost their own minority engineering enrollments, they also become advisors to high school students to fill gaps they see in the public education system. "The public schools aren't doing their jobs," says Tavada. "That's why we have our summer programs. The students aren't being encouraged to take math and science."

In a freshman engineering orientation class she teaches each fall, Marion Blalock, director of Purdue's minority engineering program, sees the results of her program's high school efforts. When Blalock asks how many of the students have participated in introductory programs,

85 to 90% raise their hands. "Very few come on their own," says Blalock. "That to me suggests that if it weren't for these programs, we'd have very small numbers coming in each year—smaller than we already have."

Sherita Brown, a senior engineer at Northrop Defense Systems Division in Elk Grove Village, IL, participated in IIT's summer program while a student at Lindblom Technical High School in Chicago. She later earned bachelor's and master's degrees from IIT. Now in talking to students in Chicago's public schools, she sees fires of ambition burning in few students' eyes.

"The students seem surprised that someone my age—26—could be where I am today. I grew up on the south side of Chicago in a housing project; now I'm working at Northrop and I live in [the suburban community of] Palatine. They can't understand that it's not a matter of having a lot of luck; it's a matter of self-motivation and determination. I don't see the look in their eyes that says 'I can do it.'"



James Witherspoon, senior engineer: Without the support of the college professor who became a mentor, "I'm certain I would have left the university and gone to a junior college."

The poor quality of public education continues to dog students once they enter college. The dropout rate for black and Hispanic students enrolled in undergraduate engineering programs is higher than that for white students. As a result, an important component of minority engineering programs at the college level is the free tutoring and counseling the programs provide.

But another aspect of the support programs is the camaraderie they offer. Support programs try to alleviate the deeply felt sense of isolation that minority students can experience at a predominantly white campus. "The point is not to hold their hand forever," says Miranda. "But in the first two years of college, it's crucial for them to find a place at the college, know they can make it, and get the help they need if they're falling behind."

When Danny Creed, a supervisor at AT&T Information Systems' Computer Systems Division in Naperville, IL, attended IIT in the middle 1970s, the minority engineering program there was in its early stages and offered few support services. In lieu of formal programs, a strong sense of community developed among the school's minority students. "Coming from an all-black neighborhood and an all-black high school made going to a predominantly white college a culture shock," says Creed. "The minority community that develops is very important to give you the psychological lift you need to let you know you're not alone."

When James Witherspoon arrived at Arizona State University in 1977, the campus had few minority students and no support services. Without the psychological anchor he found in a professor who became his mentor, Witherspoon says he would most likely have abandoned his pursuit of a bachelor's degree. Enrolled as an engineering major, he had taken neither chemistry nor physics in high school. He immediately found himself unprepared for the courses he was required to take.

Teaching a physics class to which Witherspoon was assigned was a professor who saw past his lack of academic preparation and recognized his potential. The professor pointed him in the direction of books and other materials that would give him the background information he needed. "Had he not been there, I'm certain I would have left the university and gone to a junior college," says Witherspoon, now a senior engineer at Harris Corp's government systems sector in Melbourne, Florida. "I felt I was outclassed and in over my head." He went on to complete the undergraduate program and earn a master's degree in electrical engineering. He is now finish-

ing a dissertation on robotics and computer architectures for his doctoral degree.

In addition to the ordinary pressures of heavy workloads and the burden of educational disadvantages, minority men and women face racial prejudice even in the ostensibly enlightened environment of higher education. When IIT was starting up its minority engineering program in the middle 1970s and the school's minority enrollment was rising, the school newspaper began printing letters to the editor that contained racial comments. Creed recalls students writing that the school's admission standards were being lowered and grades inflated in order to accommodate more minority students. "I was determined to prove that wrong," says Creed. "I was determined not to let those comments become a self-fulfilling prophecy."

Witherspoon's encounter with one professor is evidence that racial bigotry is far from extinct. Enrolled in a course on dynamics in mechanical engineering, Witherspoon found his teacher would not look him in the eye or call on him even when his was the only hand raised. "I was very proud," he recalls, "and I insisted on doing what I knew was right." He continued to sit in the front row and raise his hand to answer questions. He received high marks on all of his homework for the class. For a final grade, Witherspoon—an A and B student in his other classes—received a D.

After being told by the dean of engineering that any grade change would have to be made by the professor, Witherspoon went back to the professor. "I swallowed every iota of my pride and went into his office and asked him to explain how he derived my grade." Witherspoon then explained to the professor why he believed his grade was wrong. "He sat back in his chair and told me if I wanted a different grade, I could retake the course, pure and simple." To offset the D on his record, Witherspoon took the course the following summer and earned an A.

More subtle forms of racism can be just as threatening to a student's self-esteem and career plans. At Purdue University, a minority student with a 4.0 grade point average received from one professor a recommendation that called him "the best minority student I've ever had." Says Howard Adams, director of the National Consortium for Graduate Degrees for Minorities in Engineering, "You just don't get any better than a 4.0." Those kind of qualifying remarks can hurt students who plan to apply for additional fellowships to continue their studies.

The minority engineering program at the University of Massachusetts in Amherst mixes its academic preparation with a dose of reality by sponsoring frequent seminars at which industry representatives counsel students in what the workplace holds for them. The message, says Tavada, is "be careful who you hire with, and don't become just a statistic for a company that wants to meet its EEO requirements."

There are no centers for information about how minority engineers fare once they enter the labor market, but anecdotal evidence indicates minority engineers often encounter a work environment that uses two sets of standards to gauge professional competence—one for white engineers, and one for minority engineers. "Many minority students are coming back and saying that in many cases, although certainly not all, you have to be twice as good as your white counterpart in order to make the same types of promotions," says Thomas. "They get the feeling that they're not allowed to be average—they have to be sensational."

To provide students of all ages with an idea of engineering's requirements at the professional level, many minority men and women give freely of their time to talk with students and serve as role models. Anitra Wilson, a former engineer for Texas Instruments who is completing her master's degree at the University of Florida in Gainesville, tutors local high school students in math and science as part of the Southeastern Consortium for Minorities in Engineering, an Atlanta-based organization. "All black engineers have a responsibility to put something back into their communities," says Wilson. "With the conservative movement in the country, we can't afford not to network and to help each other as much as we can."

When Sherita Brown went to work for Northrop in 1983, she was one of the first black women to work in the company's mechanical engineering department. Since then, she has worked with company representatives to recruit more minority engineers. She volunteers through the Society of Women Engineers as a counselor for the University of Illinois, and as a representative for Northrop's Youth Motivation Program she speaks with local high school students.

Like Brown, Creed has become a role model for new engineers at his company. As manager of a group developing software for AT&T's line of computer equipment, Creed encourages his staff to offer career assistance to engineering students who work at the company each summer. "What we try to impress on new engineers is that they have an obligation to be a mentor and advisor to summer employees."

"The perception still exists that engineering is a white male profession," says Anitra Wilson, "but we're changing the stereotype every day through our accomplishments." **EDN**

Part 1 of this article appeared in the May 15 issue of EDN.

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1986 Editorial Calendar and Planning Guide

Issue Date	Recruitment Deadline	EDN Editorial Emphasis	EDN CareerNews
June 12	May 21	Digital Technology Special Issue; Personal Computer Boards; Development Systems (CAE-related*); Computer ICs; NCC Show Preview	Closing: 6/19 Mailing: 6/30
June 26	June 5	CAE Systems; Communications ICs; Military Microcomputers; Semicustom IC Design (CAE-related*)	
July 10	June 19	Product Showcase—Volume I; IDs & Semiconductors; Hardware & Interconnection Devices; Power Supplies/Sources; Software; Literature on Computers & Peripherals, Components, Test & Measurement Instruments, International Products	
July 24	July 2	Product Showcase—Volume II; Computers & Peripherals; Components; Test & Measurement Instruments; International Products; Literature on ICs & Semiconductors, Hardware & Interconnection Devices, Power Supplies/Sources, Software	
Aug. 7	July 17	Resistors; CAE; Communications ICs; Microprocessor Development Software; Technical Article Database Index	Closing: 8/14 Mailing: 8/26
Aug. 21	July 31	Military Electronics Special Issue; High-speed ICs; Communications Technology	
Sept. 4	Aug. 14	Test & Measurement Special Issue; Oscilloscopes; Automated Design & Engineering for Electronics Product Preview (CAE-related*); Meters; Display Technology	Closing: 9/11 Mailing: 9/23
Sept. 18	Aug. 27	Personal Computer-Based CAE; Power ICs; Computer Peripherals; Hardware & Interconnection Technology; EDN 30th Anniversary Tribute	
Oct. 2	Sept. 11	Surface Mount Technology; Memory ICs; CAE; Semicustom IC Directory (CAE-related*)	Closing: 10/16 Mailing: 10/28
Oct. 16	Sept. 25	Digital Signal Processing; Personal Computers; ICs; Test & Measurement Instruments; Display Technology	
Oct. 30	Oct. 8	Batteries; Converters; Wescon '86 Product Preview; European Electronics; Computer Boards	
Nov. 13	Oct. 23	Wescon '86 Show Issue; Op Amps; CAE; Semicustom ICs (CAE- related*); Artificial Intelligence (CAE-related*)	Closing: 11/3 Mailing: 11/25
Nov. 27	Nov. 6	Microprocessor Technology Report & Directory; CAE; Passive Components	
Dec. 11	Nov. 18	Product Showcase—Volume I; ICs & Semiconductors; Hardware & Interconnection Devices; Power Supplies/Sources; Software; Literature on Computers & Peripherals, Components, Test & Measurement Instruments, International Products	
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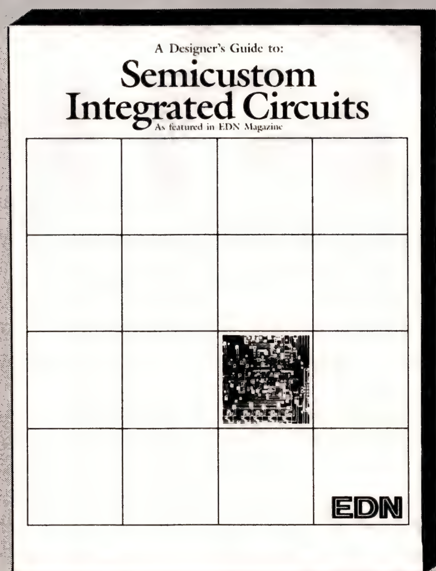

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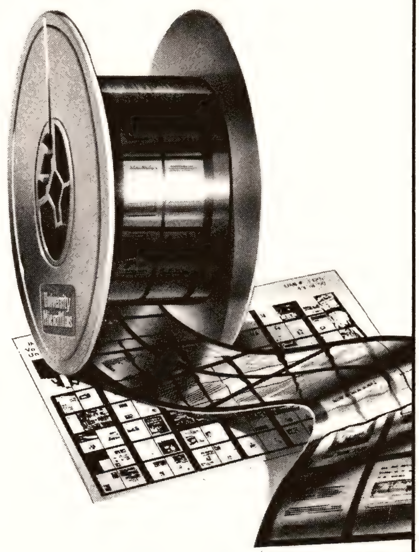

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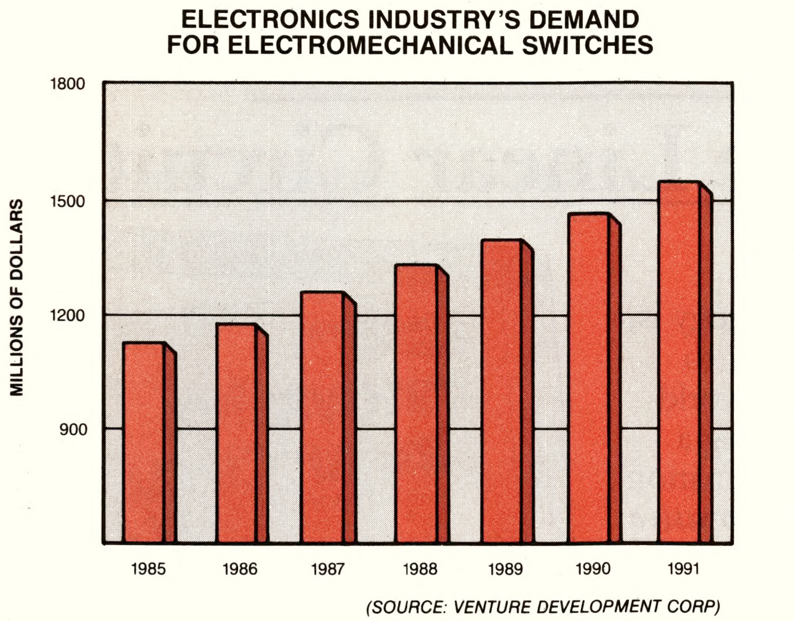

Market niches key to growth in US switch market

The electronics industry's demand for electromechancial switches could grow at a 5% annual rate from 1985's $1.1 billion to approximately $1.5 billion by 1995, reports Venture Development Corp (VDC), a Natick, MA-based market-research concern. Although many types of switch products constitute mature markets, says VDC, specific segments will show above-average growth and thus key the overall market surge.

In the US, the market is essentially a rebounding one. One factor deemed responsible for recent reductions in shipments of switches by US manufacturers to domestic and international buyers is a worldwide recession experienced by the electronics industry. In addition, says VDC, the strength of the dollar has proven double trouble: Favorable foreign exchange rates have given manufacturers from other countries an opening into US markets, while the same rates have retarded US corporations' entry into foreign markets.

Consumption of pushbutton, rocker, DIP, and keylock switches will experience above-average annual growth during the remainder of the decade, reports VDC, with DIP- and keylock-switch makers enjoying the highest growth rates. Pushbutton switches will account for more than twice the market share of any other switch product by the end of the decade.

VDC states that users are demanding smaller switches with lower current ratings, and thus purchases of miniature and subminiature parts will increase throughout the period. A number of alternative technologies—keypads, electronic solid-state switches, ICs, sensing switches, etc—will challenge electromechanical types, but the displacement of electromechanical switches by these other devices will be gradual. Many OEMs prefer to stay with the low-cost, simple, reliable electromechanical technology.

Europe semi makers rebound via start-ups and alliances

A reverse in the trend toward European companies' dwindling share of the world semiconductor market is not only possible but likely, says Malcolm Penn, director of Dataquest's (San Jose, CA) European operations, in a recent issue of the Semiconductor Equipment and Materials Institute Inc's *Semioutlook*. The two prime factors in this change of fortunes, says Penn, are the formation of strategic alliances—among European manufacturers as well as with overseas makers—and the emergence of the European semiconductor start-up company.

Recent signs of a healthy turnabout, reports Penn, include the good performance since 1981 of Plessey (UK), Ferranti (Italy), SGS (Italy), and Thomson (France). In general, though penetration of non-European markets increased only 5% from 1979 to 1985, "[a] mere doubling of this figure to 10%, which is not too aggressive a target, would increase European companies' worldwide market share to 16% and their exports to 50% while maintaining their present 40% share of the European market . . . [These goals] are readily achievable," says Penn.

Important strategic alliances include the "megaproject" of Philips (The Netherlands) and Siemens (Federal Republic of Germany). The project will aim to develop a state-of-the-art process for building 4M-bit dynamic RAMs and 1M-bit static RAMs. Thomson and MEDL (UK) have announced their intention of cooperating in the development of application-specific ICs. Among the notable start-ups, says Penn, are Mietec (Belgium), Integrated Power Semiconductors (Scotland), and ES2 (pan-Europe).

"The seeds of cooperation across national and international barriers have already been sown, both at component and end-equipment levels," Penn notes. "We believe this trend will continue. There is no place for blinkered nationalism in the global markets of the 1990s."

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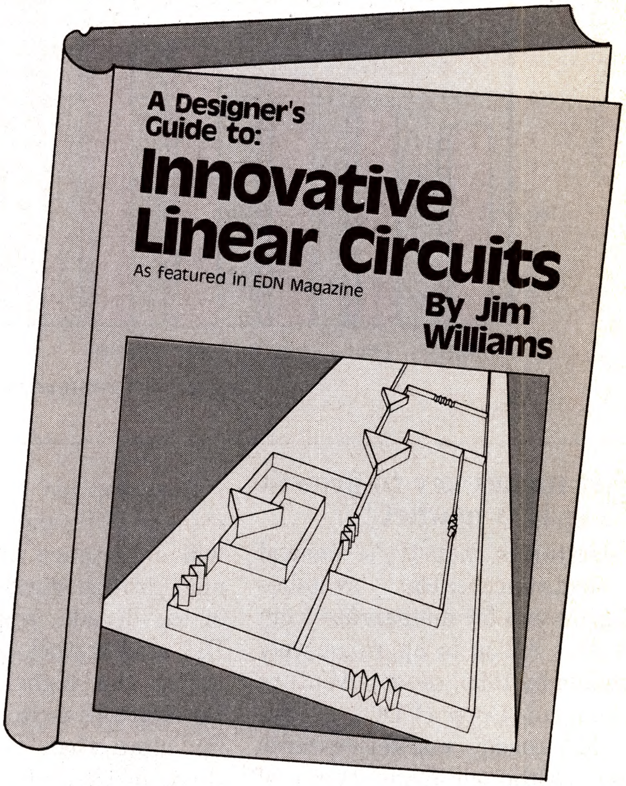

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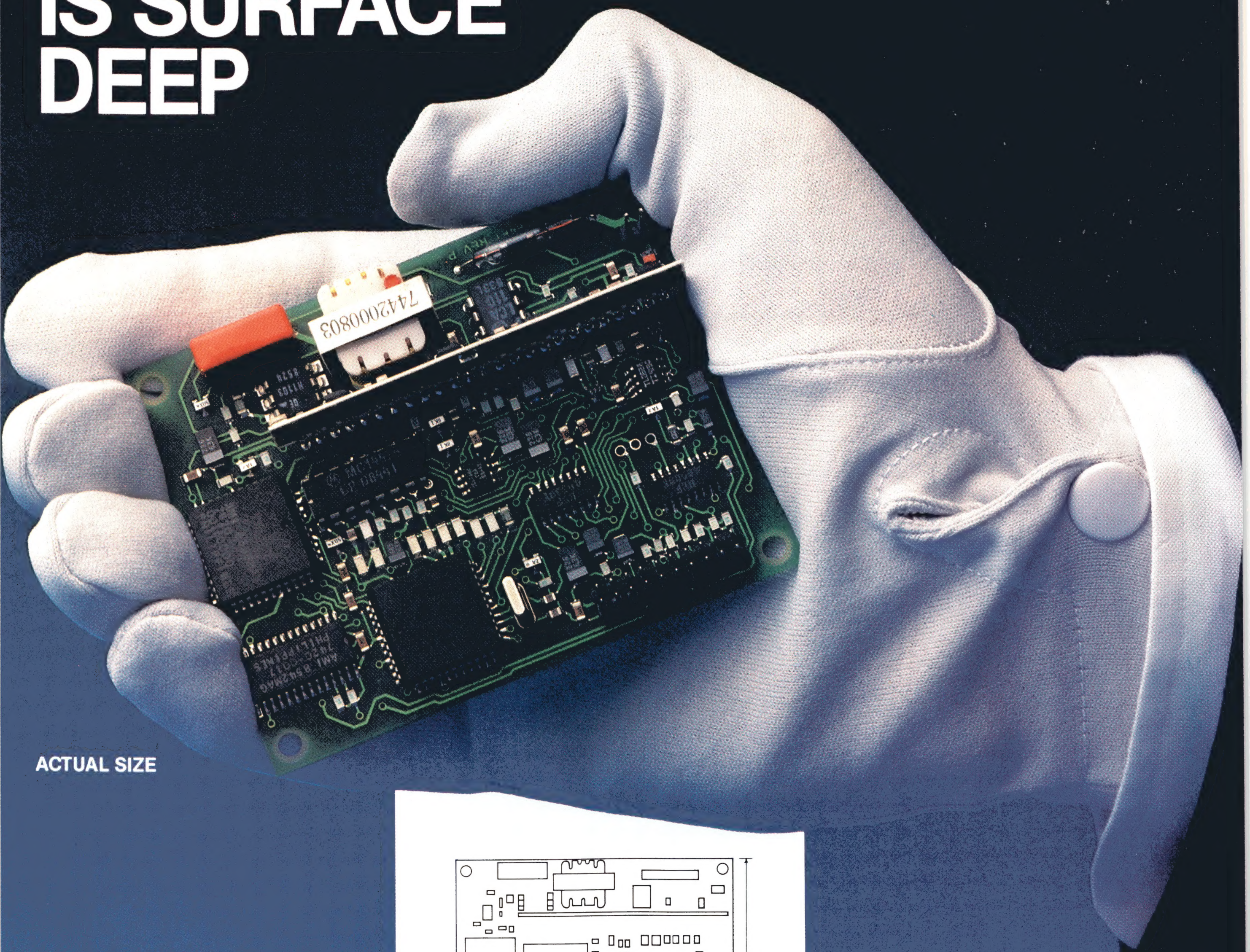

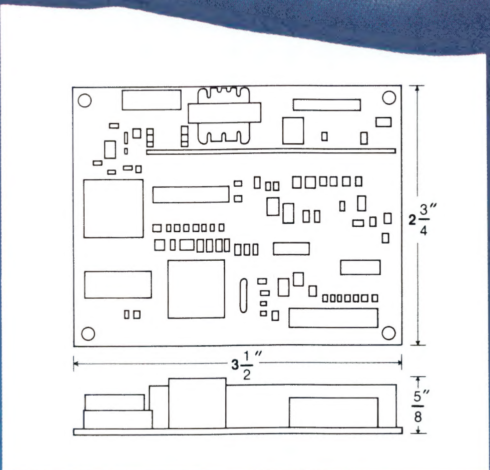

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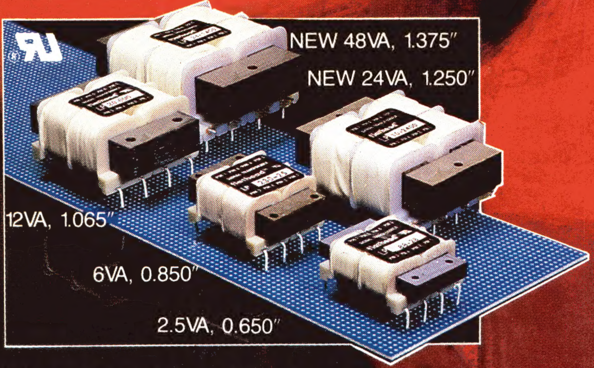

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